POWER

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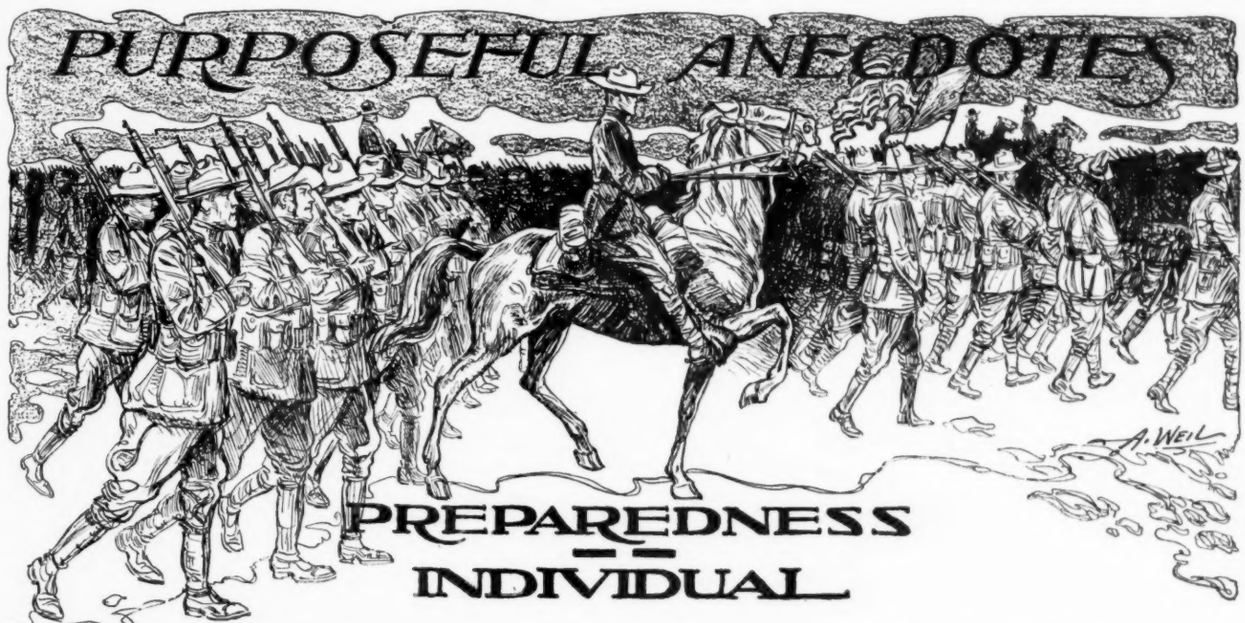


The "Safety First" slogan's long season of popularity is waning, and now the uptodate writers and speakers are preaching "Preparedness," either military, naval or industrial. We submit another—"Individual Preparedness." While it has no relation in this instance with war, as of nations, it is the kind that serves for both defense and conquest in the struggle for existence and eminence in the engineering profession.

CHAPTER I

IT WAS 4:15 p.m. No. 3 shift had replaced No. 2 in the power plant of the Wellby-Coles Co. Everett, the young operator in charge of No. 3 shift, had just finished looking over the day's log when the telephone called him. Taking down the receiver, he heard the chief's voice at the other end.

"Hello—Everett?"

"Yes."

"I just wanted to tell you," said the chief, "that the senior engineering class from the university at Oakley is coming over to have a look at the plant this evening. You can expect them about 8 o'clock, I suppose, for I understand they are to leave Oakley at 7."

"All right, sir; I'll be ready for them."

Accordingly, a few minutes after 8 the students, numbering about a hundred, reached the plant. No time was lost in getting to the business of the evening, and Everett soon was busily occupied in answering questions about the different pieces of apparatus. And when it comes to asking questions, the engineering-college student visiting a power plant has it all over any other branch of the human species. At least so thought Everett. One of the visitors—an elderly man—even wanted to know his name!

CHAPTER II

Six weeks after the visit of the engineering students to the power plant of the Wellby-Coles Co., Everett received by mail a letter inclosed in an official-looking envelope postmarked Chicago. Wondering who could have written to him from that place, he opened it up. Inside he found a letter which read:

Do you remember the elderly man who accompanied the students from Oakley through your plant about six weeks ago? The writer is that man.

I am the general manager of the firm of Boyd & Boyd, which operates power plants in various sections of the country. My son was attending college at Oakley, and I happened to be visiting him when the students went through the plant in which you are employed. I accompanied the students on the trip, and I was very favorably impressed with the way you conducted the students around and the readiness with which you answered their questions. In fact, I quizzed you myself on a thing or two that I am afraid the ordinary operating engineer would have hesitated over. But you were "on the spot" with the answer and made it so plain that even an outsider could follow you.

One of my theories is that when a man knows every detail of his business so well that he can explain it intelligently to an entire stranger, he is a good man to have around. This letter is to offer you a place as chief engineer in a new plant we are building at Harmon. This is not to be as large as some of our other plants, but if you will consent to come, I believe we can agree on a salary that will be satisfactory to both of us. As a further incentive, I can promise you that there is plenty of room for you to expand if you make the effort. Judging from what I already know of you, you will need no urging to do this.

Kindly let me know as soon as possible how you feel about making a change and about when you can come. The sooner the better, as you can become familiar with the details of construction of the plant at Harmon while it is being erected.

Very truly yours,
J. A. Boyd.

The foregoing is a true account—only the names are fictitious—of how one man evolved to the chief-engineership of an important plant. The fundamental reason for his success is that HE KNEW HIS BUSINESS—knew it so well that even a stranger in the plant could recognize his worth. Opportunity had to knock but once, and she found him worthy. In other words, he was prepared. He stepped into success because he had been building—fitting himself for it by improving his *little* opportunities. He took care of the *little* opportunities as they came along, and the BIG one took care of itself.

Contributed by H. G. GIBSON, *Washington, D. C.*

Burning Coke Breeze

SYNOPSIS—Coke breeze is a waste product of the coke oven. It is burned in the ordinary boiler furnace with difficulty and is generally carted away from the ovens at an expense resulting in no returns. This article describes a system for burning this kind of fuel. It consists of an overfeed stoker, special grates and a steam-jet or a blower-type of forced draft. Coke breeze containing between 25 and 35 per cent. ash will evaporate about 6 lb. of water per pound of dry fuel.

Coke breeze is to the coke industry what the culm pile is to the coal mine. Each represents a fuel that at one time had no value, although containing sufficient heat units to warrant burning, if means could be found to burn it. The solution of the culm pile has been found in the washery; that of coke breeze in a mechanical stoker.

Coke breeze is the refuse that is taken from coke ovens when they are drawn. Many attempts have been made to burn beehive-oven coke breeze under hand-fired conditions with varying degrees of success. One of the difficulties has been to keep firemen because of the arduous labor. During the summer months there is the extreme heat to which the men are exposed both from the natural temperature of the boiler room and from the radiant heat from the furnace when firing or cleaning the fires is in progress. There is also the additional weight of fuel to be handled necessary to develop the required rating of the boilers, thus increasing the labor of the firemen over that required if a fair grade of coal were being used. Owing to the many difficulties encountered, hand-fired coke breeze with the ordinary grate and design of furnace is not successful. About 1896 a series of experiments in burning this fuel under return-tubular boilers were carried on by Charles N. Hays in connection with Robert Ramsey, Sr., superintendent, and later with O. W. Kennedy, general superintendent, and Mr. Parker, chief mechanical engineer, of the Frick Coke Co., Mt. Pleasant, Penn. At the initial stage of these experiments no special furnaces were used and the same relative distance between the grates and the boiler was maintained as when burning coal.

It was soon found that the fuel required a forced draft to furnish the necessary air supply, and the steam-jet type was used. A special pattern of shaking and dumping grate was also designed. Before the proper ratio of grate to boiler-heating surface to give the best results was determined, a number of changes were necessary and the proportion of air space in the grates was changed several times; the air pressure in the ashpit was also altered. Whenever a change or combination of changes was made, tests were conducted until a standard of grate surface, air space and blower capacity for different types and sizes of boilers was decided upon.

There are two kinds of coke breeze—one from beehive, the other from byproduct coke ovens. It is impossible to handle the fuel in other than a quiescent or an unagitated state. The use of stokers that agitated the fuel resulted in the formation of a mass of clinkers sufficient to compel the shutting down of the plant after a few hours' run, while the fires were being cleaned. Operating under such conditions would make the cost of maintenance practically prohibitive and the labor-cost would be about one-third greater than under hand-fired conditions.

The average coke breeze produced contains from 25 to 35 per cent. of sand, sulphur and fire-clay, all of which go to make up a considerable clinker formation. The necessity of handling these materials is what led to the development of an overfeed stoking system that distributes the fuel evenly over the grate surface from above the top of the fire bed. The principle of the stoker system is that the fuel flows through the hopper (see Fig. 1) by gravity onto a pusher plate, from where it is precipitated into an impelling chamber by the pusher that is operated by a rocking arm in contact with a cam, or from an eccentric attached to the rocking arm. The impellers distribute the fuel over the fuel bed at any required amount up to that necessary to operate the boiler greatly in excess of its normal rating. Fig. 2 shows a front view of the stoker.

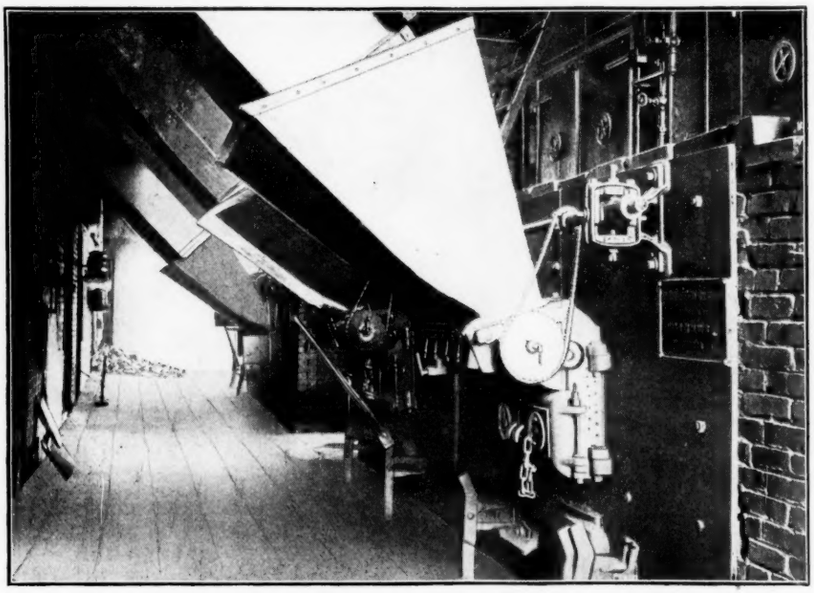


FIG. 1. STOKERS HANDLING COKE BREEZE

To handle the clinkers produced in burning coke-breeze fuel, a specially designed rocking, cutting and dumping grate is used (Fig. 3). The fuel bed is carried about 8 in. thick at the front of the furnace, and as the grates are pitched, a depth of 18 in. is carried at the bridge-wall. At intervals the grates are operated for shaking; that is, the points of the grates are dropped about 3 in., and as the clearing space between the bars remains the same, nothing but fine ashes is sifted to the ashpit. The shaking movement is so slight that the fire bed is not disturbed to any great extent. This movement also prevents the amalgamation of clinker-forming impurities.

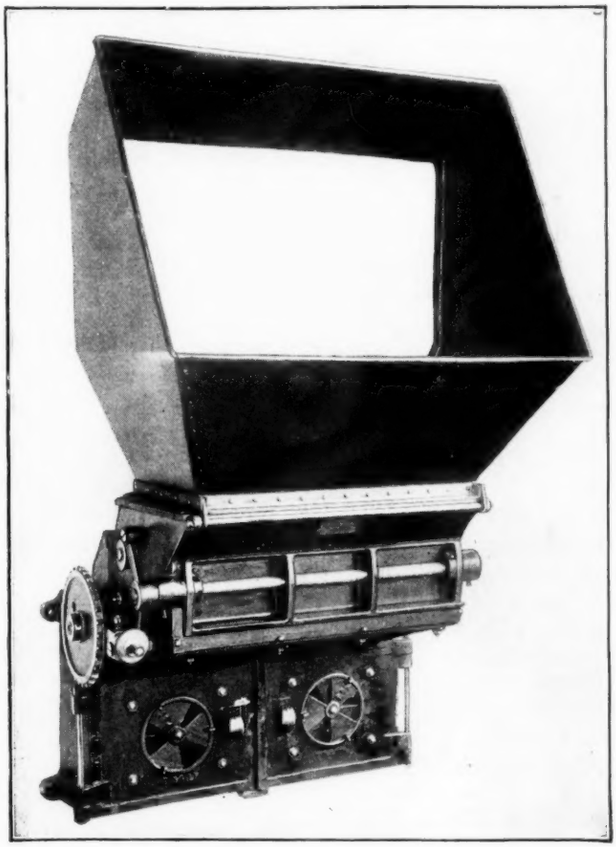


FIG. 2. FRONT VIEW OF STOKER

The fuel bed as carried by this system[1] is divided into three zones (Fig. 4). The first is about 5 in. thick at the front to 15 in. at the back. This residue formation diffuses the air over the grate area and prevents blowholes in the fire that would be caused by an unequal air pressure. The second fuel zone is carried about 3 in. thick all over the grate surface and is composed of the incandescent particles of carbon in the fuel. The third zone is the green fuel that is continually sprinkled over the second zone. The moisture in the fuel is evaporated by the heat from below and also by the heat reflected

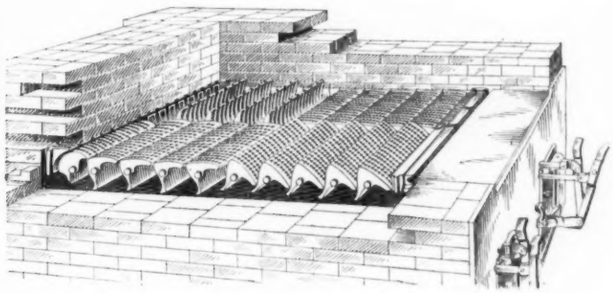


FIG. 3. DUMPING, SHAKING AND RUNNING POSITION OF THE GRATES

from the arch above. During the process of combustion the impurities are separated from the combustible and work their way through the layer of residue forming the first zone, where they come in contact with the cold air and are chilled before they become fused in large quantities with one another.

With this kind of fuel it is necessary to operate the cutoff movement of the grates about every two hours, which removes about 1 in. from the bottom of the residue at each stroke. In this way the fires are cleaned without disturbing the fuel bed and without the use of fire tools. The grates used have a 40 per cent. air space, and sufficient steam is used under them to insure the chemical decomposition of the clinker-forming properties.

[1]Charles N. Hays Co., Pittsburgh, Penn.

TESTS OF 80-HP. FIRE-TUBE BOILER AND COKE-BREEZE FUEL

1	Date	Aug. 11, 1910	Aug. 22, 1910	Aug. 23, 1910	Aug. 31, 1910	Sept. 1, 1910
2	Duration of trial, hr	8	8	8	8	8
3	Grate area	27	27	27	27	27
4	Water-heating surface	960	960	960	960	960
5	Kind of fuel	48 hr. hand drawn	72 hr. mach. drawn	72 hr. mach. drawn	72 hr. mach. drawn	72 hr. hand drawn
6	Steam pressure	74.5	83	81.8	86.4	88.2
7	Temperature of steam	319.4	325.89	325	328.36	329.64
8	Temperature of feed water	72.0	68	74	72	71
9	Total amount of fuel consumed as fired	5,275	5,950	7,000	5,958	6,217
10	Moisture in fuel, per cent	3.51	3.14	3.05	5.24	7.03
11	Dry fuel consumed	5,089.85	5,763.17	6,786.5	5,645.8	5,779.94
12	Total ash	1,756	1,269	1,886	1,850	1,768
13	Per cent. of ash	34.50	22.02	27.79	32.76	30.59
14	Total combustible	3,333.85	4,494.17	4,900.5	3,795.8	4,011.94
15	Dry fuel per hour	636.23	720.39	848.31	705.725	722.49
16	Combustible per hour	416.73	561.65	612.56	474.475	501.49
17	Moisture in steam, per cent	0.75	0.6	0.7	0.6	0.75
18	Total water apparently evaporated at working press.	24,708	30,049.5	34,080	28,900	30,181
19	Total water actually evaporated at working press.	24,502.69	29,869.2	33,841.44	28,726.6	29,954.64
20	Factor of evaporation	1.180	1.186	1.1803	1.182	1.184
21	Equivalent water evaporated from and at 212 deg. F.	28,913.17	35,424.87	39,942.5	33,826.84	35,394.29
22	Equivalent water evaporated from and at 212 deg. F. per hour	3,614.15	4,428.11	4,992.81	4,228.355	4,424.286
23	Water actually evaporated per lb. dry fuel at working press.	4.81	5.18	4.98	5.08	5.18
24	Equivalent water evaporated per lb. dry fuel from and at 212 deg. F.	5.68	6.14	5.88	5.99	6.12
25	Equivalent water evaporated per lb. combustible from and at 212 deg. F.	8.61	7.88	8.15	8.91	8.82
26	Dry fuel burned per sq.ft. grate surface per hr.	23.56	26.68	31.42	26.138	26.75
27	Dry fuel burned per hp. per hr.	6.07	5.61	5.86	5.75	5.63
28	Water evaporated per sq.ft. heating surface per hr. from and at 212 deg. F.	3.76	4.61	5.2	4.40	4.608
29	Commercial hp. developed	104.76	128.35	144.72	122.56	128.23
30	Commercial hp. rating of boiler	80	80	80	80	80
31	Per cent. of rated hp. developed	130.95	160.45	180.9	153.174	160.3
32	Efficiency of boiler and furnace, per cent	49.7	52.74	53.73	56.04	55.21
33	Calorimeter temperature	267	274	271	275	273
34	Stack temperature	485	540	537	561	532
35	Steam for blowers, per cent	12.5	8.11	7.46	8.05	7.4
Proximate fuel analysis	Carbon	58.66	67.37	59.12	62.13	61.03
	Moisture	3.51	3.14	3.05	5.24	7.03
	Volatile	12.58	6.73	8.69	6.07	8.62
	Ash	28.76	25.90	32.19	31.80	30.35
	Sulphur	0.83	1.085	1.140	1.025	0.759
	B.t.u.	11,017	11,241	10,568	10,323	10,704
		Original blower	Improved type larger capacity blower			

Byproduct coke-oven breeze does not contain the same nature or quantity of clinker-forming properties as beehive-oven breeze, and a two-stage turbo-blower is used because it has a greater efficiency than the steam blower

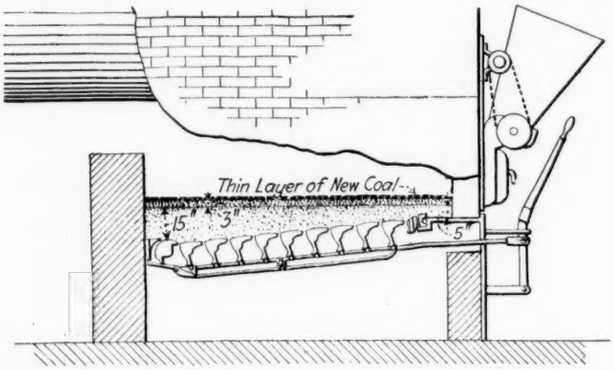


FIG. 4. A DEEP BED OF ASHES IS CARRIED

and it is not necessary to saturate the air with steam to the same extent as with beehive breeze.

The accompanying table is a record of tests made on an 80-hp. fire-tube boiler, the furnace of which was equipped with an overfeed stoker.

The water evaporated per pound of combustible from and at 212 deg. F. for the tests averaged 5.96 lb. This evaporation may seem low, but it is from a fuel that has had no market value, and in fact has had to be hauled away at an expense for which there has been no return.

The efficiency of the boiler and furnace averaged 53.48 per cent. for the tests, which is low as compared with what would be expected when burning a better grade of fuel. However, several items that are not apparent on the surface enter into the results obtained. The ash content of the fuel is high, there was no arch over the fires, and the direct contact of the gases with the cold boiler shell and the limited area for the expansion of the gases all naturally affected the combined efficiency, and increase the cost of a unit quantity of steam.

In burning fuel of this kind, it is not so much what boiler and furnace efficiency is obtained as it is what the operating expenses are and whether the burning of coke breeze is cheaper in dollars and cents for fuel and labor than other methods of operation.

The boiler plant shown in Fig. 1 contains four 80-hp. return-tubular boilers, all equipped with the overfeed type of stoker and system for burning coke breeze. The plant supplies steam for the mine pumps of the Oliver & Snider Steel Corporation, near Uniontown, Penn. The coke breeze burned is brought to the plant on a narrow-gage railroad and dumped into a bin above the stokers.

The intensity of the fires is governed by the speed at which the stokers are run and the force of the steam jet at the blower. The fuel gives an intense heat, and no trouble is experienced in burning it.

Power Factor Explained

By F. A. Annett

SYNOPSIS—A simple explanation of inductance and capacity, employing both the mechanical and water analogies; their effect on power factor, and the relation between kilovolt-amperes and kilowatts.

In a direct-current system, if a constant pressure of E volts is applied to a circuit having R ohms resistance, the current I, in amperes, that will flow in the circuit will equal $\frac{\text{volts}}{\text{ohms}}$, or $I = \frac{E}{R}$ (Ohm's Law). For example, when a resistance of 1.5 ohms is connected across the terminals of a 105-volt direct-current generator, what will be the current set up in the system? $I = \frac{E}{R} = \frac{105}{1.5} = 70$ amp., which is the value of the current after it has reached a steady flow. A fact frequently overlooked is that the current does not instantaneously attain a constant flow, but gradually increases to a normal value. This is illustrated in Fig. 1, where the current in amperes and the pressure in volts have been plotted on the vertical ordinate to the same scale and the time in fractions of a second along the horizontal. Starting at the point marked zero, which represents the closing of the circuit, the full pressure is instantly applied as shown by the line marked "volts." However, instead of the current at once reaching a normal value, it gradually increases, in the first tenth of a second reaching a value of 43 amp., in two-tenths about 60 amp., in three-tenths 65 amp., and in one second approximately normal value, or 70 amp. At this point the current curve becomes parallel with the voltage.

This gradual building up of the current is similar to starting a machine with a heavy flywheel, during the period of acceleration of which energy is being stored up in the moving mass. Just as energy is stored in the moving mass, energy is also stored in an electric circuit. In the latter, however, the storing of energy while the current is increasing is due to the magnetic field set up by the current and is more pronounced in a circuit consisting of a coil of wire wound on an iron core than in a straight conductor or coil in open air. After the machine has been accelerated, if the source of driving power be removed, it will continue to keep in motion for a period, coming to rest gradually as it expends the stored energy in overcoming friction. Likewise, when an electric circuit is opened, the current does not come to rest instantly but gradually, as evidenced by the spark at the switch. This is always more marked when the current is heavy or where the circuit is a coil of wire wound on an iron core, such as, for example, the field coils of an electric machine. The field current, even in machines of considerable size, is comparatively small; but if this circuit is interrupted a severe spark occurs, and if the circuit is opened suddenly a very high voltage is produced, which is likely to break down the insulation of the windings. Similarly, a machine with a heavy flywheel cannot be

brought to rest suddenly without wrecking the machine. If an ordinary incandescent lamp be connected in parallel with a coil of wire wound on an iron core, such as a lamp connected across the field terminals of a generator, and the switch is closed to a source of an electric current, as in Fig. 2, a current will be set up in the system as indicated. After the current has reached normal value, from the circuit; therefore, it would not be expected to seriously affect the flow of the current. However, in an alternating-current circuit where the current is changing back and forth very rapidly, it might be expected that this property (inductance) would have some effect upon the flow of the current. This statement is borne out by referring to Fig. 1. Here it will be seen that

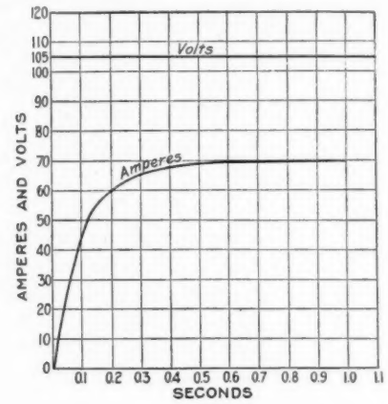


Fig. 1

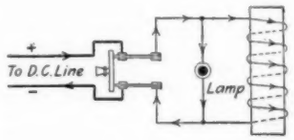


Fig. 2

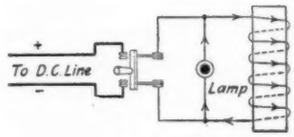


Fig. 3

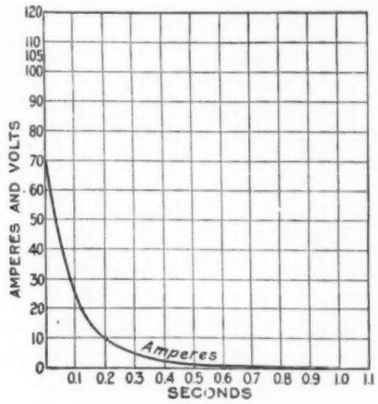
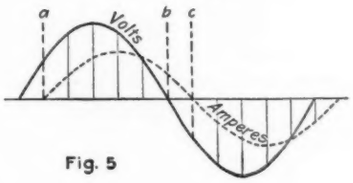


Fig. 4



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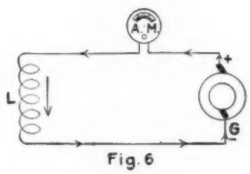
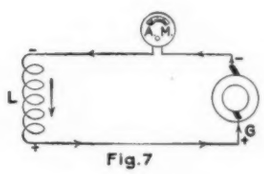


Fig. 6



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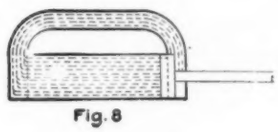
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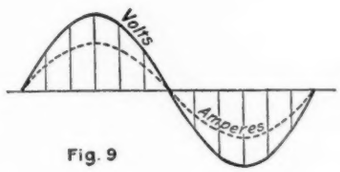


Fig. 9

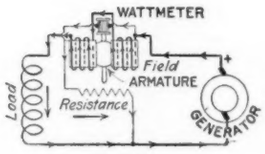


Fig. 10

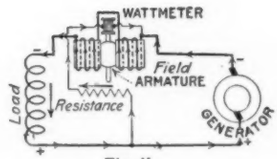


Fig. 11

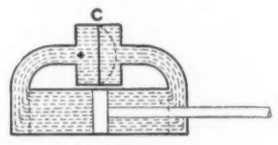


Fig. 12

FIGS. 1 TO 12. ILLUSTRATING LAG AND LEAD OF CURRENT IN A CIRCUIT

if the switch be opened, the lamp will continue to burn for a short period, because of the energy stored in the magnetic field, although disconnected from the circuit. The direction of the current through the lamp and coil after the switch is opened is indicated in Fig. 3. From this it is evident that the current does not suddenly come to rest, but has a tendency to keep in motion just as the machine did with the flywheel. Fig. 4 illustrates what takes place in the circuit described in Fig. 1, when the source of electromotive force is removed; instead of the current coming to rest instantly, it gradually decreases as shown by the curve.

The foregoing is evidence of what is called the law of inductance, first stated by Lenz and known as "Lenz's Law." Briefly stated, this is in part: "Whenever the value of an electric current is changed in a circuit, it creates an electromotive force by virtue of the energy stored up in its magnetic field, which opposes the change."

What has been shown in Figs. 1 to 4 is that the current lags behind the electromotive force, reaching its normal or zero value an instant later than the voltage. With direct current this occurs only upon opening and closing the switch or when the resistance of the circuit is changed, such as when devices are added or removed if the circuit is allowed to remain closed for only $\frac{1}{10}$ of a second, the current would increase only to about 43 amp. before it would decrease again. Fig. 5 shows the effect of inductance in an alternating-current circuit. The full-line curve represents the impressed voltage, whereas the dotted curve indicates the current that passes through its maximum and zero values an instant later than the electromotive force. At the point *b* the electromotive force is zero, but the current in the circuit is of considerable value and does not decrease to zero until point *c* is reached. Between these two points the electromotive-force curve is below the time line, while the current curve is above. This indicates that the current is flowing opposite to the voltage of the generator, which does not seem in accordance with the law governing the flow of current in a circuit.

Consider what takes place in an alternating-current circuit: In Fig. 6 a generator *G* is connected to a load *L*. Assume the electromotive force to be building up a polarity as shown. When it has reached a value indicated by *a* on the curves, Fig. 5, the current is zero; beyond this the current increases in value in the same direction as the electromotive force. This continues until the instant *b* on the curves is reached; here the electro-

motive force of the generator has become zero, but not so with the current. When the current begins to decrease, it sets up in the circuit an electromotive force which tends to keep it flowing just as in the direct-current circuit. At the instant the voltage of the generator becomes zero, the electromotive force induced in the circuit is of a value and direction such as to keep the current flowing. Thus the conditions are reversed—the generator becomes the load and the load the generator. From points *b* to *c* on the curve the load sets up a current through the generator, as indicated in Fig. 7, just as the coil in Fig. 3 set up a current through the lamp after the switch had been opened. Also, from points *b* to *c* the voltage due to inductance is decreasing, while that of the generator is increasing in the opposite direction. At *c* the voltage of the generator has increased to a value equal and opposite to that due to the inductance, and the current becomes zero. Beyond this point the current reverses and again flows in the same direction as the generator electromotive force. This is what happens at each reversal of the current. The ammeter in the circuit, Figs. 6 and 7, not only reads the current that is flowing from the generator, but also that flowing from the load to the generator. From this it is obvious that the ammeter reading will be too high where inductance is present in the circuit, and this will be referred to later.

Pump Analogy of Alternating Current

A physical analogy of the action of an alternating current in a circuit is given in a valveless pump, Fig. 8. If the piston be oscillated back and forth in the cylinder an alternating current of water will be produced in the system. The pressure applied to the piston not only has to overcome the resistance due to the friction of the water on the sides of the cylinder and pipe, but has also to overcome the inertia of the water, first in getting it started from rest at the beginning of the stroke, and again it has to bring it to rest at the end before it can start in the opposite direction. This is similar to what took place in the alternating-current circuit Figs. 6 and 7. The electromotive force of the generator not only had to overcome the resistance of the circuit, but also the back pressure induced by the changing value of the current.

In the water analogy it would not be correct to say that the total force applied to the piston is useful in keeping the elements in motion. At the beginning of the stroke work had to be done in getting the mass in motion, and again at the end of the stroke in bringing the mass to rest; consequently the power supplied to the piston may be divided into two parts—a useful component overcoming the friction of the system and keeping the mass in motion, and another that is used in overcoming the inertia of the elements. This latter component might be considered as not doing any useful work, for at the end of the stroke it has to undo that which it did at the beginning.

In an alternating-current circuit, as the current increases in value it produces a back pressure in the circuit; therefore the total electromotive force produced by the generator is not effective in overcoming the ohmic resistance of the circuit, but part of it is used in overcoming the inductance. Similarly, on the latter half of the alternation, as the electromotive force decreases to zero the current does not come to rest with it but sets up an electromotive force which tends to keep the current flowing; consequently the generator will have to apply pressure in the opposite direction to bring the current to rest. Hence it would not be proper to consider that the total pressure is useful in setting up a current in the circuit, but instead it is made up of two components—one a useful component, which overcomes the ohmic resistance of the circuit, and another component which overcomes the inductance.

Apparent Watts and Useful Watts

In a direct-current system the volts multiplied by the amperes equals the watts transmitted in the circuit. This is also true in an alternating-current circuit where the current is in step with the electromotive force, as shown by the curves Fig. 9. However, such a condition is rarely true in practice, the current being usually more or less out of step with the volts. It has been shown that in an alternating-current circuit where inductance is present, the voltmeter and ammeter readings give too high a value for the effective volts and amperes, therefore the product of these two readings will give too high a value for the useful watts. For this reason the product of the volts multiplied by the amperes in an alternating-current circuit is called "apparent watts." A wattmeter will read the useful watts, or "true watts," transmitted irrespective of the relation between the currents and electromotive force.

Why a wattmeter will read the useful watts transmitted in the circuit will be evident by referring to Figs. 10 and 11. Assume the current and electromotive force to be building up a polarity as indicated in Fig. 10, the current having a direction through the wattmeter elements as shown by the arrowheads. While the current is increasing, part of the energy is stored up in the magnetic field and is not available for doing useful work. Inasmuch as the wattmeter registers the product of the volts and amperes, it will therefore be registering too high a value for the useful watts on the first half of the alternation. As the current dies down in the circuit, the effect of inductance is to keep it flowing.

Why a Wattmeter Reads Useful Watts

In the Figs. 5 to 7 it was shown that when the electromotive force of the generator decreased to zero, the current did not, but for a period the load supplied current to the generator. The effect of this condition upon the wattmeter is shown in Fig. 11, from which it will be seen that the current through the movable element is reversed from that in Fig. 10, but is still flowing in the same direction in the current coils. Reversing the current in one element only will reverse the torque of the instrument—that is, it will have a tendency to turn backward. The backward torque continues from points *b* to *c* on the curves, Fig. 5, which is just enough to offset the excess reading of the meter on the first half of the alternation. Beyond point *c* the current builds up in the same direction as the electromotive force and the process is repeated.

The product of volts multiplied by amperes (apparent watts) in an alternating-current circuit is usually called "volt-amperes," and is equivalent to the actual watts

in a direct-current circuit. In direct-current work the number of kilowatts is expressed by the formula kw. $= \frac{\text{watts}}{1{,}000}$. The term kilovolt-amperes (kv.-a.) is used in alternating-current work and equals $\frac{\text{volt-amperes}}{1{,}000}$. It is general practice to rate all alternating-current generators, synchronous motors, synchronous condensers and transformers in kilovolt-amperes instead of kilowatts. The ratio of the apparent watts to the true watts $\left(\frac{\text{kw.}}{\text{kv.a.}}\right)$ is called the "power factor." By transposition four other formulas are obtained, namely:

Watts = volt-amperes × power factor; volt-amperes = watts ÷ power factor; kilowatts = kilovolt-amperes × power factor; and kilovolt-amperes = kilowatts ÷ power factor.

The following problems will illustrate the application of the foregoing formulas:

1. Find the power factor of an alternating-current circuit when the voltmeter indicates 450 volts, the ammeter 50 amp. and the wattmeter 20 kw.

$$\textit{Volt-amperes} = 450 \times 50 = 22{,}500 \ (\textit{apparent watts})$$

$$\textit{Kilovolt-amperes} = \frac{\textit{volt-amperes}}{1{,}000} = \frac{22{,}500}{1{,}000} = 22.5$$

$$\textit{Power factor} = \frac{\textit{kilowatts}}{\textit{kilovolt-amperes}} = \frac{20}{22.5} = 0.89$$

(or 89 per cent.)

2. What size of generator is required to supply a load of 35 kw. at 85 per cent. power factor?

$$\textit{Kilovolt-amperes} = \frac{\textit{kilowatts}}{\textit{power factor}} = \frac{35}{0.85} = 41.2$$

The power factor is always less than one except when the current is in step with the electromotive force. Under such a condition the true watts and apparent watts are equal, which condition is referred to as unity power factor. In the second problem one of the effects of low power factor is manifested, namely—the generator has to be of larger capacity to supply the load when the current is out of step with the electromotive force than when they are in phase; therefore it is desirable to keep the power factor as near unity as possible.

So far only inductance has been mentioned as affecting the relation of the current to the electromotive force. There is, however, another element present known as capacity, or in other words, the property of a condenser. The effect of capacity in an alternating-current circuit is the same as inductance only in the reverse order; that is, inductance causes the current to lag behind the electromotive force, while capacity causes the current to flow ahead of the electromotive force.

Capacity has the same effect in a circuit as would be experienced if a chamber *C* with an elastic diaphragm across it were placed in the pipe line, Fig. 8. Fig. 12 shows this arrangement. If the piston is pushed toward one end of the cylinder, the diaphragm will be distorted as indicated by the dotted line, to accommodate the water displaced from the cylinder. Distorting the diaphragm creates in it an effect against the motion of the piston, so that when the piston is reversed, the energy stored in the diaphragm will assist in reversing it. The energy stored in the diaphragm is opposite to that stored up in the moving mass due to inertia. If the mass did not possess inertia, or the energy stored in the mass were less than that stored in the diaphragm, the piston and water would reverse sooner than the force applied to keep it in motion. Capacity has a similar effect in an alternating-current circuit, by causing the current to reverse before the electromotive force, just as inductance prevented the current from changing its direction in the circuit until a very short interval after the electromotive force had changed its direction.

The relation between the current and electromotive force in a circuit where capacity only is present is represented in Fig. 14. Here it will be seen that the current passes through its zero and maximum values an instant earlier than the electromotive force and is said to lead the voltage. The power factor of such a circuit is called a leading power factor, while that of an inductive circuit is called a lagging power factor. In Fig. 12, if the pressure due to distorting the diaphragm is equal to the inertia of the mass, the water and piston will move back and forth in time with the force applied. Similarly, in an alternating-current circuit, if the inductance and capacity are made equal, the current

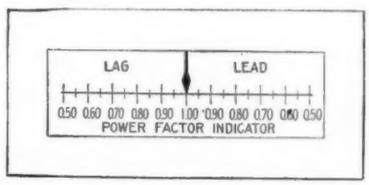


FIG. 13. SCALE ON POWER FACTOR INDICATOR

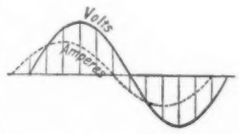


FIG. 14. ILLUSTRATING LEADING CURRENT

will flow in step with the electromotive force, as indicated in Fig. 9, and artificial means are frequently used to obtain this end.

Power-factor instruments have a scale similar to that shown in Fig. 13, unity power factor being indicated at the center. When the needle deflects to the right, it indicates a leading power factor; to the left, a lagging power factor. The power factor equals the cosine of the angle of lag or lead between the current and the electromotive force. Therefore the angle by which the current is out of step with the electromotive force may be found by taking the power-factor indicator reading; in a table of sines and cosines find an angle the cosine of which corresponds to this reading. For example, find the phase displacement between the current and the electromotive force if the power-factor meter indicates 0.85 on the lag side of the scale.

In a table of sines and cosines it will be found that 0.85 corresponds approximately to the cosine of a 31-deg. angle. Hence this reading would indicate that the current lags 31 deg. behind the electromotive force.

From the foregoing it is obvious that if an alternating electromotive force be impressed upon a circuit, there are three elements which affect the flow of the current—the ohmic resistance, inductance and capacity—as compared with ohmic resistance only in a direct-current circuit. The inductance and capacity in the circuit is called reactance, inductance being referred to as inductive reactance and capacity (or condenser effect) as capacity reactance. The combined effect of resistance, inductance and capacity is called the impedance of the circuit.

Developing Efficiency in Central Stations

By C. M. Rogers

SYNOPSIS—It is pointed out that in most steam-power plants of an average of 1,000-kw. capacity a saving can be made in fuel consumption by increasing the efficiency of the boiler plant. Several instances are cited where improvements were made that resulted in a saving of fuel.

There is in use today in the United States approximately 8,000,000 hp. in central stations, 4,250,000 hp. in isolated plants and 4,000,000 hp. in electric railways. There is also over 65,000,000 hp. in steam railroads and over 25,000,000 in manufacturing, etc., to which efficiency in combustion could be applied with gratifying results.

About five-eighths of the capacity of the central stations, three-quarters of the electric-railway stations, practically all of the isolated plants, and seven-eighths of the manufacturing are operated by steam.

The steam central stations alone turn out over six billion kilowatt-hours yearly and use over $45,000,000 worth of fuel. The average size of these stations is slightly under one thousand kilowatts. The boiler-room costs in plants of this size will average about 70 per cent. of the total cost of current on the switchboard, and the saving that can be effected in fuel by increasing the combined efficiencies of the boiler room is about 20 per cent. This would mean over $9,000,000 yearly to the central stations.

In no other branch of electric-power generation is there the opportunity to make savings and add to the net earnings without increasing the capitalization, interest, depreciation, etc., charges, that there is in the boiler room.

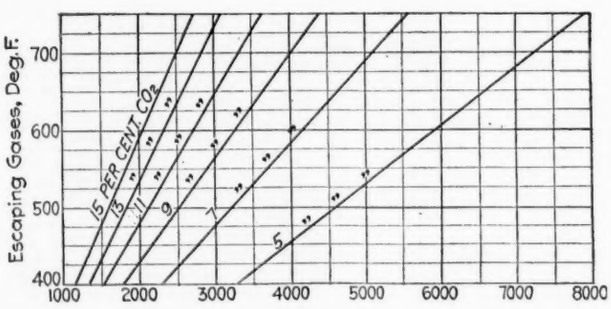


FIG. 1. LOSS FOR DIFFERENT PERCENTAGES OF CO_2 AND FLUE-GAS TEMPERATURES

Nowhere, in any other department of the average central station of the size here considered (1,000 kw.) are there as large avoidable wastes permitted as those in the boiler room.

The greatest avoidable wastes are heat lost up the stack, poor stoking, heat rejected to ash, steam leaks and leaky traps and radiation. The heat escaping up the stack is the greatest single loss around the central station, running from 10 to 40 per cent. of the fuel, and the avoidable loss can be attributed to any or all of the following reasons: Air in excess of that required to furnish the oxygen for combustion; a deficiency of air in the furnace or parts thereof, or improper design, causing incomplete combustion; scale and soot deposits on the heating surfaces, which impair the heat transmission from the gases to the water, and improper or leaky baffling, causing the gases or part of them to short-circuit or not take their proper course through the boiler.

As the losses due to incomplete combustion or the formation of CO are rarely over 1 per cent., only the sensible heat lost out the stack will be considered. The other four partly preventable losses mentioned represent a loss of between 15 and 20 per cent.

The loss of heat up the stack caused by excess air is due to any or all of the following reasons: Too much

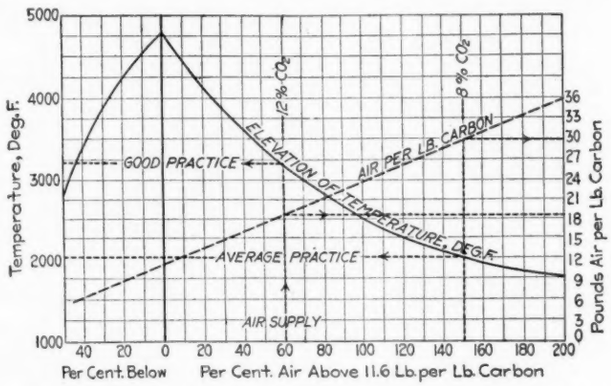


FIG. 2. DROP OF FURNACE TEMPERATURE WITH LOW CO_2

draft; air leaking through settings; air leaking around doors, drums, etc.; bare spots on grates; uneven fuel bed; too-thin fire; wrong fuel for existing conditions; improper selection of grates; improper selection of stokers; improper selection of burners (oil, gas or tar); and improper furnace design. In the average plant a saving can usually be made with the existing equipment, plus a slight expense that is almost negligible when compared with the saving effected.

The easiest and quickest ways to increase the efficiency and reduce the fuel bills are to keep the dampers in operating condition, fix dampers to operate from furnace fronts, carry the proper draft in the furnace, keep the heating surfaces free from soot and scale, keep the baffling in proper condition, carry an even fire of proper thickness on the grates, allow no thin or bare spots to occur, fire light and often (if hand-fired), stop all air leaks into the boiler furnace and maintain a high percentage of CO_2. Failure to give the proper attention to these details causes avoidable wastes in fuel. To facilitate carrying them out and maintaining a high standard of efficiency, it will be necessary to provide for part or all of the following:

Provide a CO_2 machine, equip all furnaces with draft gages, encourage use of other boiler-room instruments, keep the daily results before the firemen and provide them with necessary literature, and maintain adequate and reliable records. Last but not least are the remain-

ing principles for developing the boiler-room efficiency, which are to be used in moderation: Select the right operator for the right job, train the operators and help to educate them, make the work a pleasure, encourage advancement in each employee, consult competent counsel, plan and estimate in advance, dispatch the schedules outlined, standardize the working conditions, also the various operations, and coöperate with the plant men and command their coöperation in return.

Nothing will burn without uniting with oxygen. Air by volume is composed of approximately 21 per cent. oxygen (O) and 70 per cent. nitrogen (N). If we were to burn carbon (C) with the right amount of oxygen to obtain 100-per cent. efficiency, or perfect combustion, the product would be gas containing 21 per cent. carbon dioxide (CO_2) and 79 per cent. (N); the temperature elevation would be about 4,800 deg. F. As one pound of carbon requires 2.66 lb. O for complete combustion, this operation would require approximately 12 lb. air to furnish this amount of oxygen. Coal contains other combustibles than carbon and also some noncombustible material, so that 21 per cent. CO_2 could never be obtained, and for figuring purposes 20 per cent. will be considered the limit.

Suppose a reading of the CO_2 content in some furnace gases was 10 per cent. It would then be known that 200 per cent. of the necessary air was being furnished to the furnace and that 24 lb. of air per pound of coal instead of 12 was being supplied. The CO_2 percentage shows that only one-half of the oxygen is being used.

Here is where the loss occurs: Assume that the air is entering the furnace at 100 deg. F. and leaving the

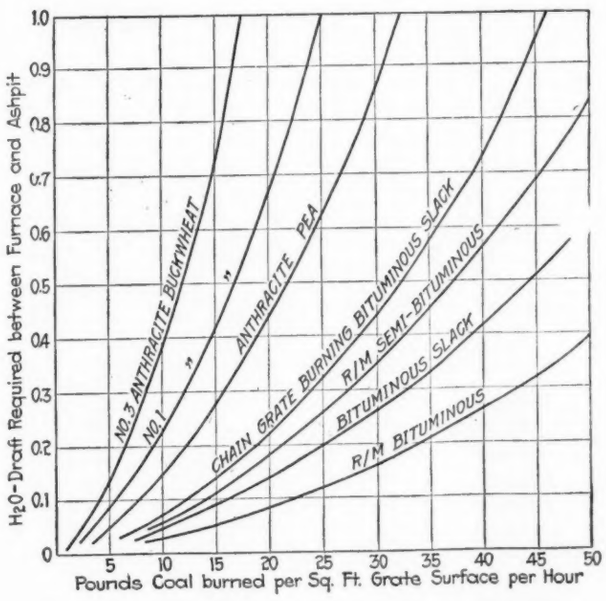


FIG. 3. CURVES FOR HAND FIRING BITUMINOUS RUN-OF-MINE

boiler at 600 deg. F. It is then being heated 500 deg. F., and as the specific heat of the gases is approximately 0.25, each pound is carrying out of the stack $500 \times 0.25 = 125$ B.t.u. Then 24 lb. (10 per cent. CO_2) is carrying out of the stack $24 \times 125 = 3{,}000$ B.t.u. Therefore, for each pound of coal burned under these conditions 3,000 B.t.u., or 25 per cent. of 12,000 B.t.u., is being wasted.

Likewise for 5 per cent. CO_2, which is not unusual in small plants, there is $(20 \times 12) \div 5 = 48$ lb. of air going through the boiler per pound of coal burned. The loss is $48 \times 0.25 \times 500$, or 6,000 B.t.u. This is about one-half the coal bill, and 75 per cent. of it is preventable.

The curves, Fig. 1, show the loss for different percentages of CO_2 and flue-gas temperatures. Fig. 2 shows how the temperature of fire drops with low CO_2. This

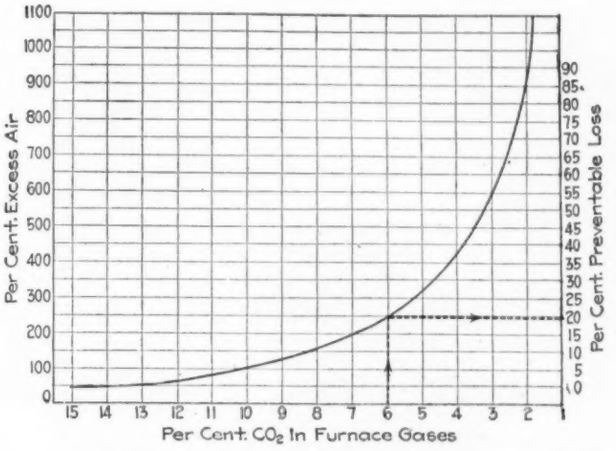


FIG. 4. LOSSES FOR DIFFERENT PER CENT. CO_2 WHEN BURNING OIL

is found by dividing the B.t.u. generated per pound of combustible by the weight of the gaseous products times their specific heat. This illustrates the necessity of providing the proper instruments and instructions.

The conditions of a few central stations where the efficiency has been increased to the extent of reducing the fuel bills over 30 per cent. is given here. One hand-fired plant contained five 400-hp. water-tube boilers furnishing steam to reciprocating engines. A high-grade soft coal was used, running about 14,600 B.t.u. and 5 per cent. ash, and consumed at a rate of 8.9 lb. per kw.-hr. This was abnormally high, although on account of the inefficient engines and the low load factor the water rate per kilowatt was 62 lb. This shows that the evaporation was about 7 lb., or a combined efficiency of 46.5 per cent. The settings and most of the clean-out doors were leaky, and most of the stay-bolt plugs were missing, thereby allowing a tremendous amount of air to enter the furnace.

The fires were carried about 20 in. thick on the front of the grates and from 3 to 6 in. thick at the bridge-wall, and firing was done only every 45 min. The coal consumption was 1 ton per hour, equivalent to a rate of burning 9 lb. per sq.ft. of grate surface per hour on the four boilers.

When a CO_2 machine and draft gages were put in service, the reason for 46.5-per cent. efficiency was solved. The average CO_2 in the last passes was 4.5 per cent. and over the fires 9 per cent. The average draft in the furnaces was 0.55 in. of water. The curve for hand-firing run-of-mine bituminous coal, Fig. 3, shows that less than 0.1 in. is required to burn 9 lb. per sq.ft. per hr. efficiently. With the proper thickness of fire any more draft will "pull air through" in excess of that required and lower the CO_2, and coal will be burned to heat air instead of water.

The dampers were in place, but could not be operated. They were immediately fixed to operate from the furnace

fronts. The firemen were then taught not to touch the ashpit doors, but to regulate the draft according to the load and the rate of steaming by the dampers in the uptakes.

The boilers were taken off the line one at a time for examination and the tubes and drums were found scaled and almost ½ in. of soot deposited on the outside. While these were being cleaned, the firemen were being instructed and other minor efficiency hazards were being overcome.

Within two weeks the fires were maintained about 8 in. thick; the draft was kept about 0.12 in. over the fire and regulated by the dampers; the firing intervals were reduced to 8 min. instead of 45, and the dust was blown from the tubes every day. The result was an increase in evaporation per pound of coal of 3.25 lb. water, making the combined efficiency average of 68 per cent. The CO_2 average was 12 per cent. in the last pass, and two boilers carried the load that formerly required four and five. The coal cost per kw.-hr. was reduced 32 per cent.

Summing up, the conditions before and after are tabulated herewith:

	Before Development	After Development
Coal per kw.-hr., lb.	8.9	6.05
Evaporation, lb.	7.0	10.25
Combined efficiency, per cent.	46.5	68
Depth of fire, in.	3 to 20	8
Firing interval, min.	45	8
Draft over fire, in. water	0.55	0.12
CO_2 last pass, per cent.	4.5	12
Coal cost per kw.	$0.0116	$0.00795
CO_2 machine	None	1
Draft gages	None	5
Saving, per cent.	....	32

In another larger plant the boiler-room economies were not in such a deplorable condition, but there was room for a saving of 38 per cent.; part of which was effected by increasing the efficiency of the then existing equipment and personnel, and the remainder by adding more efficient machinery and labor. The fuel costs were 0.65c. per kw.-hr. The coal was a high-grade bituminous run of mine, having a heating value of 14,500 B.t.u. and containing 6 per cent. ash. The CO_2 content of the gases ran about 7 per cent. and the draft over the fire 0.35. The dampers could not be operated from the floor. The boilers were found leaky and dirty. The operators had been offered no facilities that would have been conducive to more efficient handling of the fuel and the boilers.

The necessary instruments were installed, the firemen instructed, the draft controlled, the fires regulated, boilers cleaned, the air leaks stopped and the water kept at a more constant level. The CO_2 then averaged over 10 per cent. This new basis of operation resulted in a reduction in fuel cost per kw.-hr. to 0.52c.

There were several grades of cheap pea and slack available that would be excellent for mechanical-stoker operation, and a side-feed type, well-adapted to burning cheap coals, was installed. The personnel of the boiler room was changed to young, educated men. The most economical of some twelve coals was determined upon and contracted for after testing each for from 5 to 30 days. The boiler-room labor per ton fired was cut almost in half.

The size and character of the load is practically the same now as it was previously, and energy is sent out of the plant for a coal cost of 0.38c. This is a reduction of 38 per cent. and amounts to $50 per day. The CO_2 is carried at 14 per cent. since the stokers were installed and the coal changed. The draft is throttled to the least possible amount that will carry the load.

The conditions in an oil-fired plant before developing efficiency were about as follows: The plant supplies light and power by turbine-driven generators, the steam being furnished by six 600-hp. water-tube boilers. The oil consumption was 3.6 lb. per kw-hr. The average percentage of CO_2 was 5.5 and the draft in the first pass 0.35 in. The dampers could not be operated. The oil burners were inefficient—lacking in principle and design—and there was a thick accumulation of soot on the tubes.

The dampers were connected to operate from the furnace fronts, draft gages were installed, and a CO_2 machine was purchased for permanent use. With these changes it was only possible to reduce the oil consumption to 3 lb. per kw.-hr. and increase the CO_2 to 9 per cent. The draft could consistently be cut to but 0.15 in. The best efficiency under these conditions was 66 per cent., and the reason for failure to increase the same was charged to the burners.

New burners and furnaces were installed. So far, these were the only items of any appreciable expense. The result of this last change was a reduction from 3 to 2.6 lb. of oil per kw.-hr. The station is running now on 2.5 lb. of oil per kw.-hr. instead of 3.6; the CO_2 runs 14 instead of 5.5 per cent. The draft in the first pass is practically balanced instead of 0.35 in. The combined efficiency is 75 instead of 55 per cent., and the reduction in the fuel bill is $1,500 per month. Fig. 4 shows losses for different percentages of CO_2 when burning oil.

If the man directly in charge of the operations where the losses occur is lacking in efficiency, it is the fault of his superior. The responsible head has not conceived the principles of efficiency in selecting and directing his men and operations. The average manager of the small property fails in efficiency because he neglects to seek and follow competent counsel. As an illustration, in a small plant a new 80-hp. boiler was removed and a new 100-hp. installed in its place. It was found that the 80-hp. boiler that was discarded was the same size as the new 100-hp. boiler which replaced it. An overzealous salesman induced the manager to make the change, whereas a few dollars' worth of competent counsel would have saved about $2,000.

No-Spark Carbon Brushes

The commutator of a motor or generator is a vital part of the machine, and should the contact between the brushes not be of the best, the friction set up will create heating and cause sparking and cutting of the commutator.

The composition of No-Spark carbon brushes makes the brush contact almost frictionless, permits the machine to run practically noiseless at its maximum efficiency and reduces the wear on the commutator. The brushes wear smooth and will not chip, split or break; they are also moisture-proof.

The Calebaugh Self-Lubricating Carbon Co., 1511 Columbia Ave., Philadelphia, Penn., are the makers and distributors.

Pipe Threads of the Standard Briggs Design are used in the United States and should be tight under the mill-test pressure and not vary more than 1½ turns either way when tested with a standard gage.

Effect of Early Cutoff on Wiredrawing

By Thomas T. Eyre*

SYNOPSIS—An explanation of the effect of early cutoff on the wiredrawing of steam when used with a slide valve and a shaft governor.

The flow of steam through an orifice has been carefully studied and the laws of this flow formulated. The quantity of steam passing through it in a certain time depends upon the area of opening and upon the difference in pressure on the two sides of the orifice. If no difference in pressure exists, there will be no flow. For steam to flow through the ports of an engine there must be less pressure in the cylinder than in the steam chest. As the piston moves forward, the volume back of it increases; the steam to fill this volume enters from the steam chest through the port. If the area of the port is ample, there is no very great drop in pressure between the steam chest and the cylinder. If the area of the port opening is restricted, there is a considerable drop in pressure.

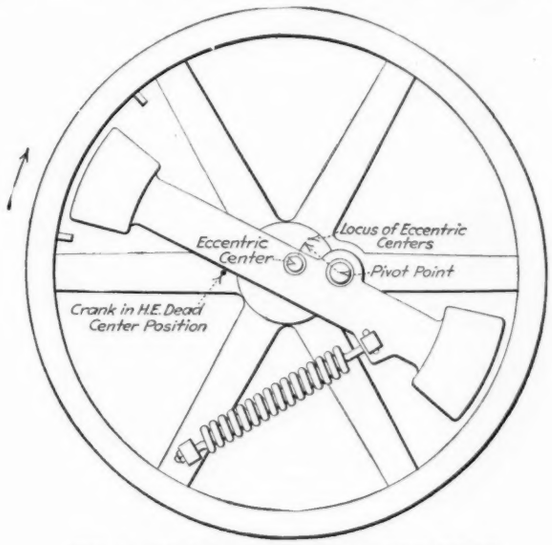


FIG. 1. ONE TYPE OF SHAFT GOVERNOR

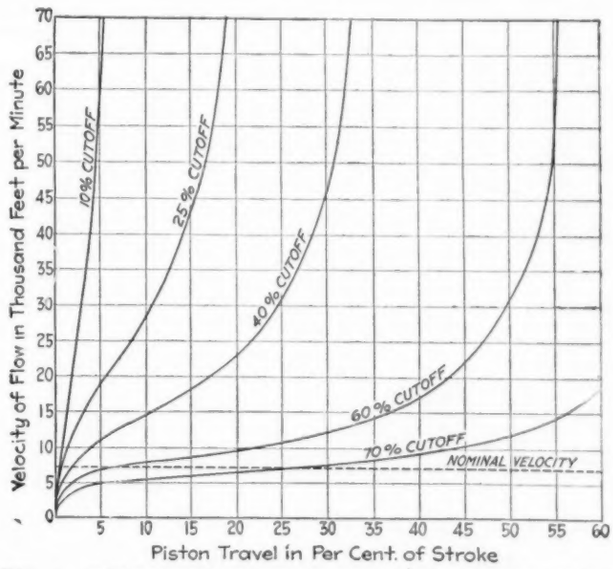


FIG. 4. VELOCITIES PLOTTED FOR DIFFERENT CUTOFF

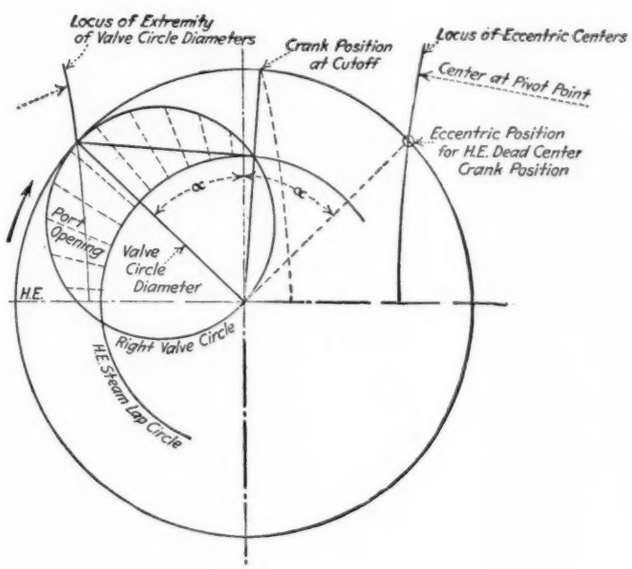

Locus of Extremity of Valve Circle Diameters
Crank Position at Cutoff
Locus of Eccentric Centers
Center at Pivot Point
Eccentric Position for H.E. Dead Center Crank Position
Port Opening
Valve Circle Diameter
H.E.
Right Valve Circle
H.E. Steam Lap Circle

FIG. 2. DIAGRAM FOR FINDING CRANK POSITION AT CUTOFF

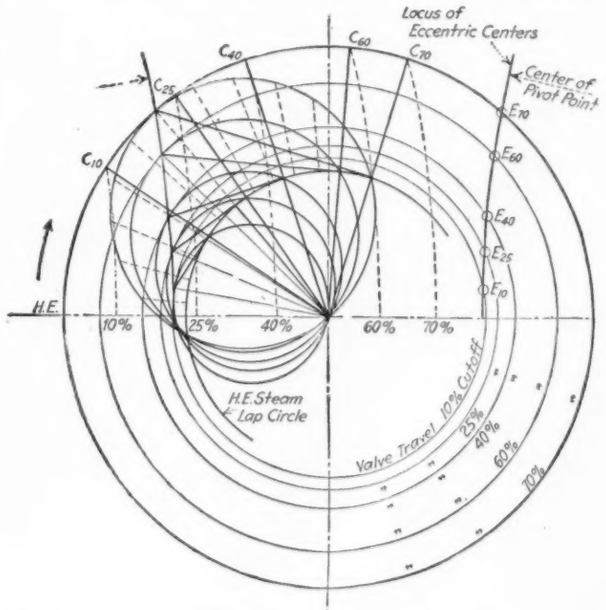


FIG. 3. DIAGRAM DRAWN FOR VARIOUS CUTOFF

This drop is commonly called wiredrawing, and if excessive, it lessens the efficiency of the engine and may also cause a pitting of the edges of the valve and port. With the slide valve as ordinarily driven by an eccentric, the area of opening near the point of cutoff is much restricted and wiredrawing results. One reason why the Corliss

*Assistant professor, mechanical engineering, Purdue University.

valve mechanism is better than that of the slide valve is because the port is kept wide open until cutoff, when the trip occurs and the valve is closed suddenly by the vacuum in the dashpot.

Many high-speed steam engines are equipped with slide valves, and the time of cutoff is controlled by an automatic shaft governor. Most of these governors control the cutoff by changing the angle of advance of the eccentric and also the valve travel. An arm which carries the eccentric is pivoted to the flywheel at a point such that for heavy loads the valve travel is large and the angle of advance of the eccentric is small, thus giving a late cutoff for the heavy load. Fig. 1 shows in outline a type of shaft governor. The governor is shown in position with the crank on head-end dead-center and is for a direct valve with its motion coming directly from the eccentric. When a heavy load is applied, the governor arm turns a small distance about the pivot point in a clockwise direction relative to the Wheel. This moves the eccentric center farther from the center of the shaft and so increases the valve travel.

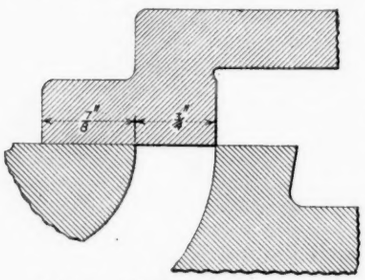


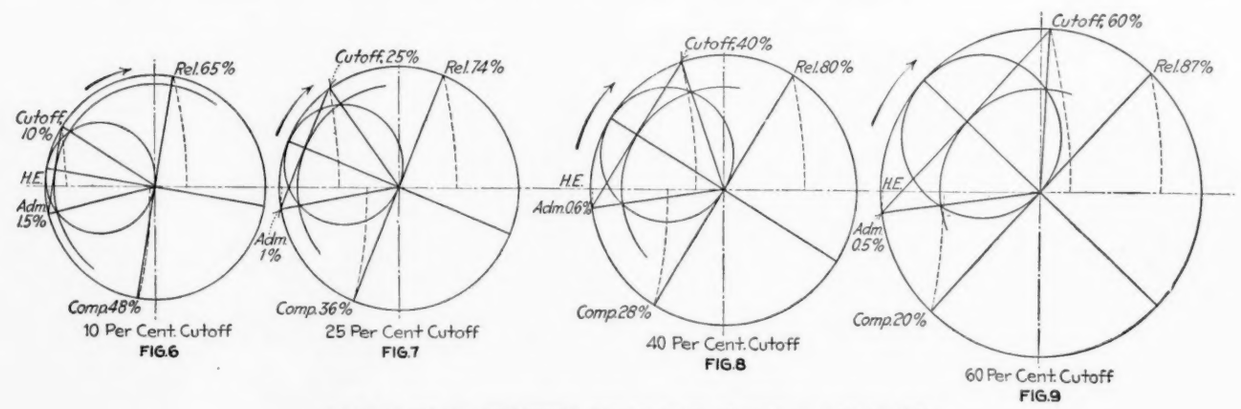
FIG. 5. POSITION OF VALVE

Fig. 2 shows by means of the Zeuner valve diagram the method of finding the crank position at cutoff for any relative position of crank and eccentric. For a direct-acting valve when the crank os on the head-end dead-center the eccentric is ahead of the crank 90 deg. plus **a**. The diameter of the valve circle is to the left of the vertical center line the same angle the eccentric is to the right of the same line, thus knowing **a**, the valve circle is locted. The intersection of the right valve circle and the head-end steam lap circle gives the crank position for the head-end cutoff. For any other position of the eccentric the extremity of the valve-circle diameter will be in a similar position on the other side of the vertical center line.

An analysis was made to determine the effect of early cutoff on the velocity of steam through the valve and therefore upon the wiredrawing. Dimensions were taken from drawings furnished by a well-known maker of engines. In this engine a slide valve is controlled by a Rites inertia governor.

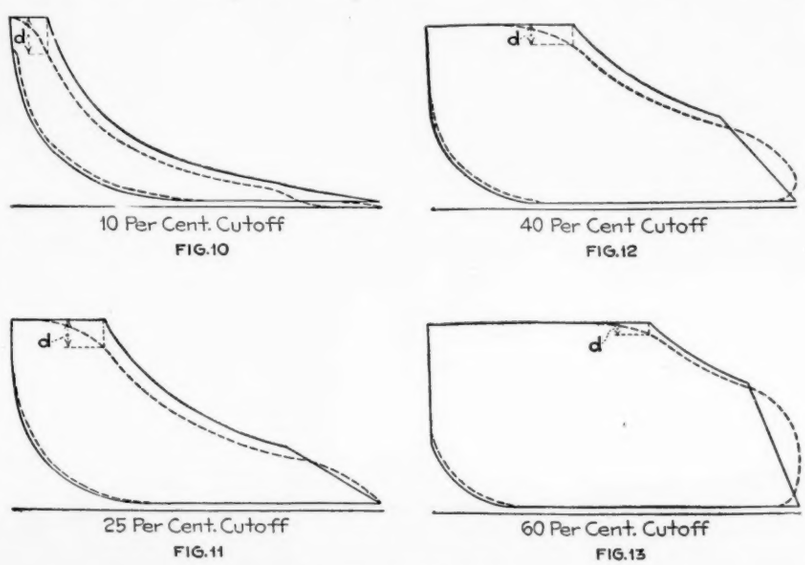
The Zeuner valve diagram was drawn for various cutoffs, and from this diagram, Fig. 3, the port opening corresponding to different piston positions was measured. The dotted radial lines of Fig. 2 give the amount the port is open at that crank position. Assuming that there is no condensation and a nonrestricted flow of steam through the port opening, the velocity of flow is computed by dividing the volume displaced by the piston in a certain small interval of time by the area of port opening. The velocities thus found are plotted as shown in Fig. 4. It is seen from this that at large cutoffs the velocity is near the nominal, while for small cutoffs it is much larger.

It is customary in designing the width of a port to assume a nominal velocity of flow of from 5,000 to 8,000 ft. per min. The cutoff at maximum load is made at 60 to 70 per cent. of the stroke. As stated, at full load the velocity is near the nominal and so but little wiredrawing occurs until shortly before the valve cuts off. However, the engine is not rated at its maximum load, but at a cutoff of 25 to 30 per cent. At this rated load the wire-



10 Per Cent. Cutoff FIG. 6 — 25 Per Cent. Cutoff FIG. 7 — 40 Per Cent. Cutoff FIG. 8 — 60 Per Cent. Cutoff FIG. 9

FIGS. 6 TO 9. SHOWING HEAD-END ZEUNER DIAGRAMS



10 Per Cent. Cutoff FIG. 10 — 40 Per Cent Cutoff FIG. 12 — 25 Per Cent. Cutoff FIG. 11 — 60 Per Cent. Cutoff FIG. 13

FIGS. 10 TO 13. THEORETICAL INDICATOR DIAGRAMS

drawing is pronounced and on lighter loads is very great. The valve used for this analysis is shown in mid-position in Fig. 5 and the head-end Zeuner diagrams in Figs. 6, 7, 8 and 9.

With the events obtained from the foregoing the theoretical indicator diagrams are drawn in full line, Figs. 10, 11, 12 and 13. With the restricted port openings near cutoff there will be a drop in pressure from that shown by the theoretical diagram. The dotted lines on these show the probable actual diagrams. It is seen from these that the loss due to wiredrawing is proportionately greater at early cutoff.

Operating Costs for Municipal Gas-Engine Plant

By H. T. Melling*

SYNOPSIS—At the gas-producer plant of the Edmonton municipal station the average cost of producing power at the switchboard, including fixed and overhead charges, was 1.688c. per kw.-hr. for 1914 and 1.513c. for 1915.

In 1908 the City of Edmonton, Alberta, Canada, installed in its electric-power plant a gas engine using producer gas generated from local lignite coal. This engine is a double-acting twin-tandem type having cylinders 24 in. diameter by 32 in. stroke and running at 150 r.p.m. It is directly connected to a 700-kw. 2,300-volt three-phase 60-cycle generator.

Compressed air at 200 lb. is used for starting and is supplied by a two-stage steam-driven compressor, which is also used in the station for other purposes. Circulating water for the engine and producers is supplied by a 4-in. two-stage centrifugal pump and a special 3½-in. low-lift pump for discharging the water back to the reservoir. Both these pumps are on one base and connected by flexible couplings to a 40-hp. induction motor.

Gas is supplied under pressure by two sets of down-draft producers which are operated alternately. Their respective sizes are 5 ft. 10 in. diameter by 7 ft. 5 in. high and 6 ft. 9 in. diameter by 8 ft. 8 in. high. Each has its own steam-driven exhauster and wet and dry scrubbers, the gas piping on the exhausters being so arranged that they can be worked on either set of producers. The gas after leaving the producers passes through a vertical tubular boiler which supplies steam for the exhauster engines, then to the wet-coke scrubber, after which it passes to dry scrubbers containing wood shavings, and finally is forced through the main dry scrubber to the gas holder.

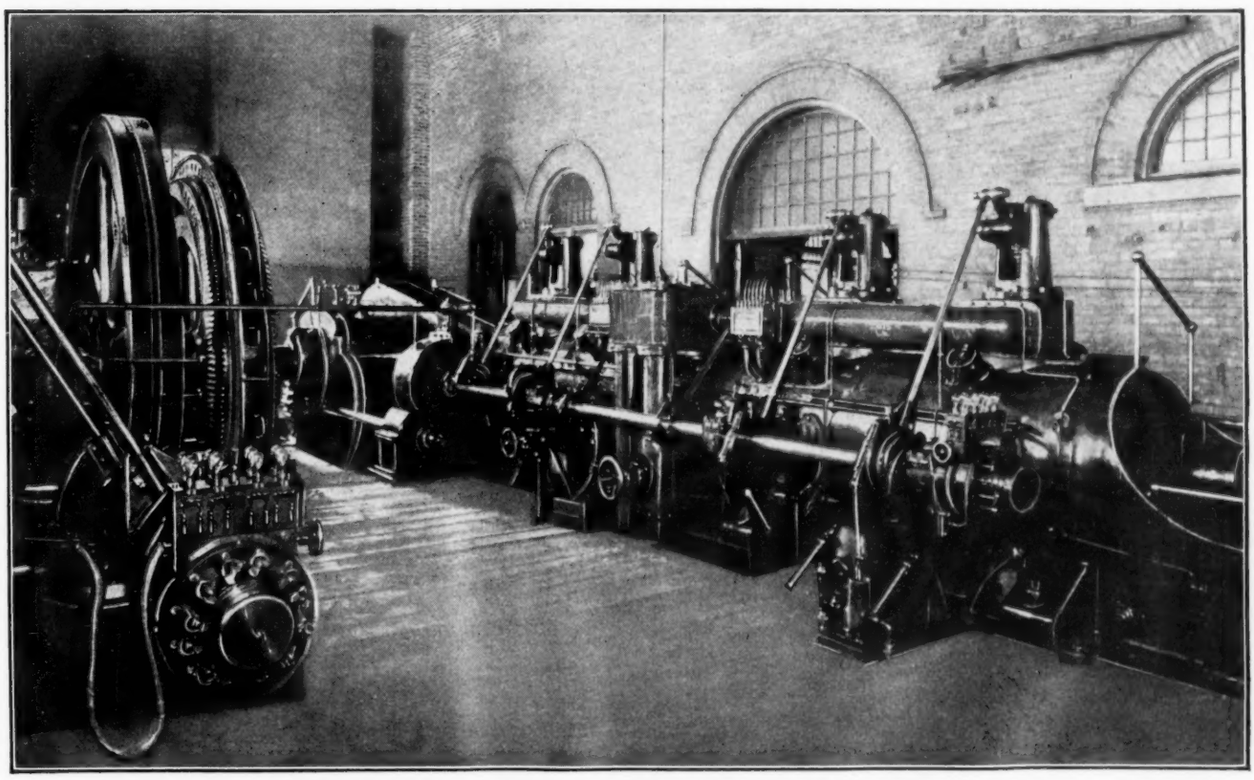


FIG. 1. TWIN-TANDEM GAS ENGINE AT EDMONTON MUNICIPAL PLANT

*Superintendent, gas power department, Edmonton, Alberta, Canada.

An average of 2,000 lb. of furnace coke is required in the bottom of the producers. This coke, when heated, destroys all the volatile matter distilled from the fresh fuel in the upper strata of the fire. Sixty per cent. of this coke is recovered on cleaning out the producers.

The actual operating time between cleaning the producers varies with the ash content of the coal from 100 hr. on the small set to 140 hr. on the large. Water is sprayed into the fires on shutting down the producers for cleaning, which greatly reduces the time and cost of cleaning. Should occasion arise, three men can clean and recharge the set and supply gas to the engine within five hours.

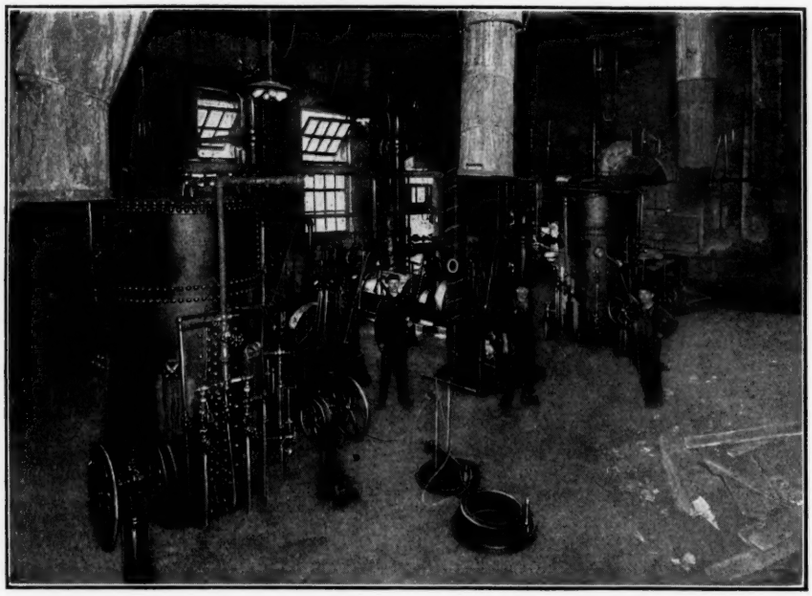


FIG. 2. VIEW OF GAS-PRODUCER ROOM

Lignite coal is used varying in price from $1.50 per ton to $2.30 delivered, the proximate analysis being: Moisture, 18.1 per cent.; volatile, 33.3 per cent.; fixed carbon, 41.3 per cent.; ash, 7.3 per cent.; calorific value per pound as fired, 9,160 B.t.u.

The gas generated contains a net heat value of 115 to 120 B.t.u. per cu.ft. To assist the producer operators, a recording gas calorimeter is connected to the gas main. The gas contains no tar, is practically free from dust and is delivered to the engine at 3 in. water pressure.

It was found that owing to the high piston speed a cylinder oil having a higher viscosity than that used on the piston rods gave the best results. Tests of the oil gave the following readings:

	Flash Point	Fire Point	Viscosity (Saybolt)	Specific Gravity, Baume
Heavy cylinder oil.....	485 deg.	545 deg.	206 @ 210	21.9
Light piston-rod oil.....	415 deg.	463 deg.	56 @ 210	25.7

The operating force consists of two engine operators, three producer operators and three producer cleaners and coal handlers, all on 8-hr. shifts.

During the first two years it was impossible to get more than half-load out of the engine and considerable trouble was experienced with scored cylinders and pistons. It was finally decided to rebore the cylinders, put in hard-metal liners and fix the plant up in the best possible condition, also to purchase an additional set of gas producers of larger capacity than the first set installed. After the plant was again put in service, a close watch was kept on its operation and costs and its troubles and defects were gradually overcome.

Daily report sheets are kept of the producer and engine operation, and an hourly kilowatt reading is taken. The actual operation and maintenance costs for the past two years were as given in the table.

OPERATING COSTS, JAN. 1, 1914, TO DEC. 31, 1915

	Jan. 1, 1914, to Dec. 31, 1914		Jan. 1, 1915, to Dec. 31, 1915	
	Total Costs	Cost per Kw.-Hr., C.	Total Costs	Cost per Kw.-Hr., C.
Coal and coke	$11,019.76	0.328	$9,312.32	0.299
Coal and coke handling, firing, cleaning producers	1,683.31	0.050	2,524.28	0.081
Firing producers' wages	2,553.23	0.076	1,229.93	0.039
Stores, waste, oil, etc	1,237.54	0.074	2,302.21	0.074
Water for engine and producers	321.51	0.010	295.01	0.009
Engine-room wages	7,525.43	0.224	6,129.81	0.199
Salaries and administration	1,795.35	0.052	1,243.71	0.040
Insurance	57.40	0.002	.....	.....
Debenture, interest and sinking fund	17,535.47	0.523	17,582.23	0.568
Cleaning producers	1,237.54	0.037	891.68	0.028
Repairs and maintenance:				
Buildings	207.64	0.006	410.13	0.013
Gas engine and auxiliaries	7,661.55	0.229	2,475.73	0.079
Producers	2,337.29	0.070	2,317.65	0.074
Generator, switchboard and lighting	222.31	0.007	316.41	0.010
	$56,628.09	1.688	$47,031.10	1.513
Hours operated	5,408.00		4,911.35	
Kilowatt-hours generated	33,545.70		31,058.00	
Pounds of coal	100,850.05		87,474.95	
Pounds of coal per kilowatt-hour	3.00		2.81	

Penco Thermo Gage

Some engineers spit on a steam trap to determine whether it is working or not. If there is no sizzle, the trap is regarded as in operation; if there is a sizzle it indicates that the trap is hot and not working properly. This method of testing is unsanitary and is objectionable. A means of ascertaining the working condition of a trap is found in the Penco thermo gage, manufactured by the Plant Engineering and Equipment Co., 6 Church St., New York City. If the gage is cold to the touch, the trap valve is tight. If it is exceedingly hot, the trap is leaking. The gage is made of brass with disk radiators (see illustration) and a spring cock extending above the trap, as shown. The pipe connection taps into the water seal above the trap valve. When the trap is tight, the radiator is filled with water. When the trap is leaking, the radiator is filled with steam. The gage can be used with any type of steam trap.

STEAM TRAP GAGE

Highly Economical Steam Turbines must necessarily be operated condensing, but there are many cases where high steam economy is not most important, and the noncondensing turbine often finds favor over the steam engine.

An Engineer's Phantom Warning--III

By Warren O. Rogers

SYNOPSIS—The phantom lady warns Westcott of an impending tube failure and endeavors to pull the fireman to a point of safety. Westcott rushes to her assistance and pushes the fireman between two boiler settings just as a tube lets go.

It was some days before I saw Westcott after his recital regarding the broken flywheel. In the meantime a tube in a water-tube boiler in one of the steam plants in the town had burst, badly scalding a fireman. The next time I saw Westcott, he was in his boiler room "jacking up" the fireman. When he had finished, we went into the engine room, where he proceeded to fill and light his corncob pipe.

"Rather an unfortunate tube accident down at the mill," I said by way of opening the conversation. "Bursting tubes are rather common, and it is no wonder seeing the severe service to which they are put. Sometimes I am surprised that there are not more."

"I had one fail in a boiler once," replied Westcott, "and it was on the occasion of another warning by the phantom lady. This happened in the plant of a manufacturing company, where we ran day and night shifts. I was on the night turn and had a fellow by the name of O'Connor for a fireman, who was assisted by a man who got in the coal and helped with one boiler.

"This night, although everything was running along the same as usual, I felt restless and uneasy and was, as a result, more watchful than usual. Somehow I felt that trouble, if any occurred, would develop in the boiler room, and I had made more than one visit to O'Connor, which surprised that individual, as I seldom bothered going to the boiler room, as he was a reliable man. I had cautioned him to be extra-careful, and he had replied with a laugh and the statement that 'a better mon niver sthood ferninst a biler.'

"There were three water-tube units, two in one battery and the other single, with a space between them. We carried 150 lb. of steam. The boilers were operated considerably above rating, and the fireman was kept rather busy making steam.

"Well, a little after midnight I made another visit to the boiler room. The load had fallen off for the half-hour lunch period, and O'Connor had checked the draft on two of the boilers and had covered the fires with fresh coal, to prevent the boilers from blowing off. When I entered the room he had closed one of the ashpit doors of the middle boiler, and stood in front of the other ready to close it.

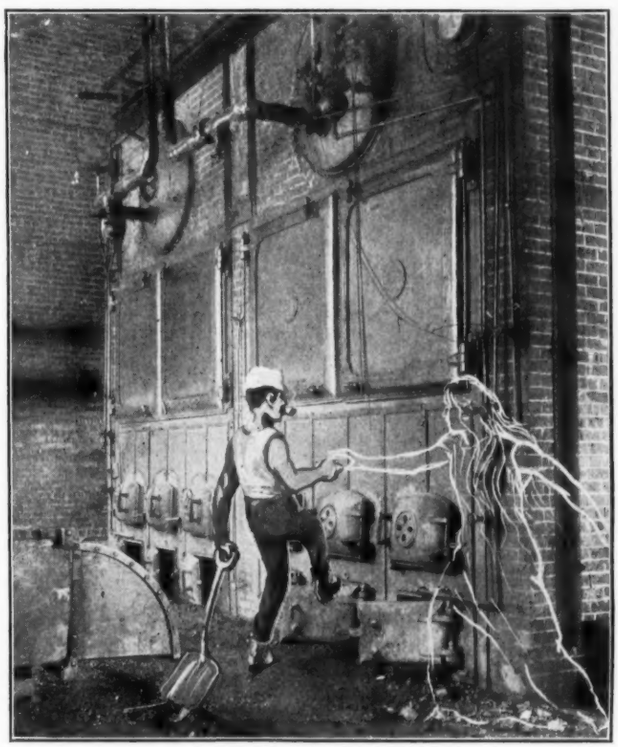
"The boiler room was not any too well illuminated, and what I saw caused me to yell to O'Connor to get in between Nos. 2 and 3 boilers. Such an unexpected order of course only caused him to stare at me in astonishment."

"Well, I don't wonder," said I. "Any sane man would have thought you had lost your senses. What made you tell O'Connor to get between the boilers?"

"That is where the phantom lady came in. As I entered the boiler room from a side door, I saw the ghost woman reaching for O'Connor's arm to try to pull him from in front of the boiler. He didn't feel the influence or see the phantom, but she was plain enough to me. Seeing that he did not move and judging by the frantic actions of the phantom that time was precious, I dashed across the boiler room and shoved him in between the two boiler settings.

"We had scarcely reached safety, when there was a roar and the boiler room was filled with steam, water and live coals. Luckily for us there was a door entering the pumproom from the back of the boilers, and we reached it without much trouble but at mighty high speed.

"The tumult soon died down, and when it got so one could return, we found that the furnace door of the middle boiler, the one in front of which O'Connor had been standing, had been blown open and the floor was covered with water and partly consumed coal. One of the tubes had burst, and had not the phantom lady given me warning, O'Connor would have been standing right in the path of the flying red-hot coals and scalding water. He wouldn't have had much of a chance by the looks of that boiler room.



THE GHOST WAS REACHING FOR O'CONNOR'S ARM

"Well, we cut out that boiler, and as the engines had been running during the rumpus, we could see to get things in shape again and finished the night run with the other two boilers without a shutdown."

"I don't see how that could be," I said in a doubting tone. "Didn't the other two boilers lose their pressure through the damaged one? Or did your guardian phantom take on the job of fireman?"

"Neither one," answered Westcott. "Those boilers were equipped with nonreturn stop valves, and as soon as the pressure in the middle one dropped a few pounds below that on the others, the valve on the damaged one closed and the other two boilers remained in service.

"As to the phantom woman having anything to do with the placing of these valves, I don't know. She might have been a factor, because in so far as I have been able to judge, it requires something more than the application of common sense on the part of some to convince them that a nonreturn valve is one of the necessities in the safe operation of a steam plant. This one saved the shutting down of the plant that time, and we ran the factory all night with but a part idle, as the two boilers could not make sufficient steam to run all."

"What became of your phantom lady?" I asked as I put on my hat and arose to go. "Disappeared as usual?"

"Well, she disappeared all right, but whether she went up through the chimney, roof or out by the door, I don't know. What's the odds?" growled Westcott a little testily. "She made good, didn't she?"

I admitted that she seemed to have had the right dope and asked what O'Connor had thought of the proceedings.

"O'Connor is, or was, a firm believer in phantoms although he has never seen one. When I told him of the warning I received as I entered the boiler room and why I had pushed him in between Nos. 1 and 2 boilers, he stood speechless for a moment, hitched up his trousers on one side, scratched his head and whispered, "Well, wouldn't that bate th' divil?"

I bade Westcott good night, and as I went out into the night musing over what had been told me, I concluded that O'Connor was right in his summing up of the case. It did "beat the devil."

New Mechanical Gas Producer

SYNOPSIS—A new producer in which all points of the grate are given equal motion. Thinner fires can be carried, a better quality of gas produced, and the capacity over hand poking doubled. Results obtained in the plant of the American Can Co.

It is generally recognized by those familiar with the operation of gas producers that when a new fire is started upon a level bed of ashes a heavy rate of gasification can be obtained from a comparatively thin layer of coal and that under these conditions the best grade of gas is made. The steam required is a minimum, and clinkers do not form to any extent. These conditions cannot be maintained in a hand-poked producer, for it is only a short while before coal must be added and frequent charging soon builds up a deep fire. The ash line becomes irregular with varying thicknesses of coal. Thin spots are likely to develop, and at these points poor gas, high in carbon dioxide, is produced, bringing down the average quality.

It is evident that if it were possible to keep a producer fire in the same condition as at starting, gas of high quality and a high rate of generation could be expected. Clinker troubles would be lessened and the labor of cleaning the fires minimized.

A mechanical gas producer said to possess the foregoing qualifications has been perfected recently by the Flinn & Dreffein Co., Chicago. In the new producer the entire fuel column, the center as well as the sides, is agitated to cause the fire to settle. The ash line is maintained at a point about a foot above the bosh, and above this a fuel bed about two feet thick is maintained.

From the sectional and plan views of the generator, Fig. 2, the construction will be evident. The entire bosh *A*, tuyere *B* and ash table *C* rest on four sliding supports, the sliding surfaces *D* being tightly housed to keep out the ash and packed with high-temperature grease. By a driving mechanism the various members just mentioned are given an eccentric motion, in which every part has the same travel, unlike plain rotation in which the motion is zero at the center and a maximum at the circumference. The bosh and tuyere arms, having a firm hold on the ash and moving in an eccentric path, are resisted by the stationary brick walls of the generator. This causes the entire column of ash and coal to rise and fall slightly along the walls with each rotation, thus settling the fire and breaking down any arching effect of the ashes which would eventually produce holes in the fuel bed.

The ash-discharge ring *G* is held fast by four extensions passing through the shell of the generator. If the fire tends to settle more on one side, then the ring is moved toward the opposite side by loosening up on one nut, holding one of the extensions through the shell and taking up on the opposite side. As the bosh and ash table

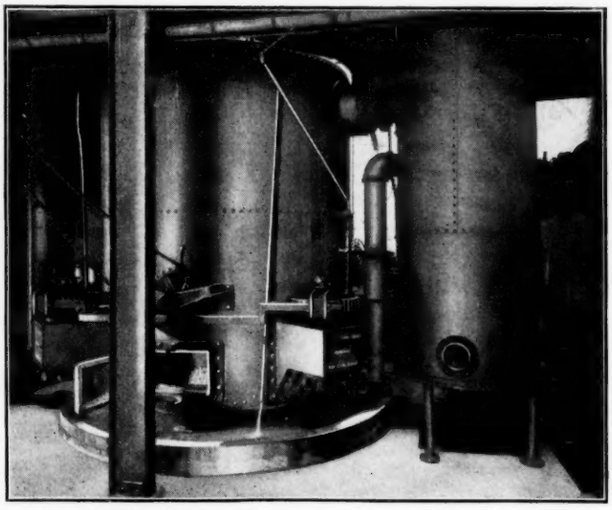


FIG. 1. PRODUCER AT PLANT OF AMERICAN CAN CO.

move and the ash ring is stationary, the relative motion results in the crushing of any clinkers formed and in pushing the ashes off the table. The ashes fall loosely into the water seal below, from which they can be removed in the regular way.

Motion is imparted to the grate by two eccentric drives mounted 90 deg. apart on the outside of the generator shell. On the vertical shafts carrying these eccentrics are ratchet wheels. Midway between these drives is a bracket carrying a horizontal shaft upon which is a sprocket-wheel chain connected to the source of power. On this same shaft is an eccentric which gives a recip-

rocating motion to a crossbar, at each end of which is a pawl for engaging the ratchet wheels imparting motion to the grate. The external part of the drive is shown to advantage in Fig. 1, which represents an installation at the works of the American Can Co., Maywood, Ill.

About four years ago this company installed three gas producers of the ordinary hand-poked type, two being 7 ft. 6 in. and one 6 ft. 6 in. diameter, the rated capacities being 300 and 200 lb. of coal per hour respectively. Anthracite at a rate of about 10 lb. per hr. per sq.ft. of cross-sectional area of the generator was used to supply

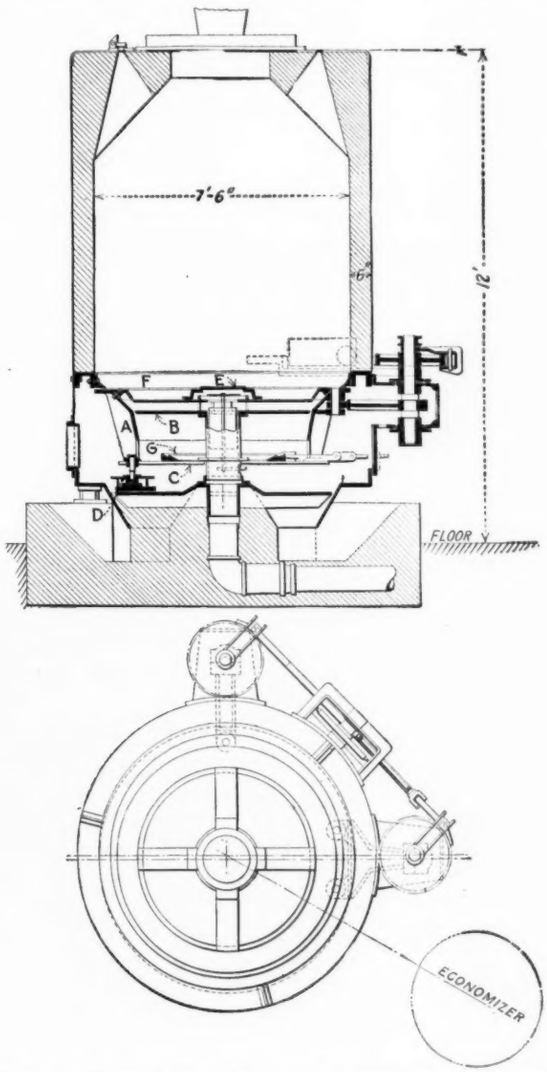


FIG. 2. SECTIONAL AND PLAN VIEWS OF PRODUCER

gas to the can-making machinery, to lacquer, japanning and varnish-baking ovens and to a number of hardening furnaces. The recent addition of a lithographing plant and increasing demand in the can works required considerably more gas. The layout of the producer room would not permit installing another generator without remodeling some of the manufacturing plant. The alternative was to install mechanically operated grates in the present producers. The two larger generators were equipped with the new Flinn & Dreffein grates.

These producers with their new grates have been in operation for a number of months. Working continuously and for long periods, they have gasified 18 to 21 lb. of coal per hour per square foot of sectional area, and on peak loads for short runs the rate has been as high as 24 lb. per hr., which may be compared to the 10 lb. per sq.ft. originally obtained.

A better and more uniform gas is being generated, and the ashes are free from carbon. Formerly the ashes had to be sifted for unburned coal. Now it is not necessary to stop operation for cleaning fires; instead, the mechanical grate is operated for a period of 1½ hr. twice during the working day, or in other words, every six hours. At the cleaning periods the operator takes readings of the height of ashes above the bosh. This is done by inserting a light bar into the fire until the end rests on the top of the bosh and measuring up to the part of the bar showing color. Records at the plant show that about 15 per cent. less coal for the same output is used than when the hand-poked producers were operated and about 10 per cent. more gas is produced per pound of coal.

Coal is supplied to the generator by a half-ton electric traveling hoist with a detachable bucket. On the first floor this is placed on a carriage and conveyed to and back from the coal storage. The bucket is then elevated to the charging platform and the coal fed to the generator as it is needed.

Gas Cleaning and Distribution

From the generators the gas passes through economizers to a common main. It then enters a coke and excelsior scrubber 6 ft. 6 in. diameter and 25 ft. high, serving the entire plant. From the top of the scrubber the gas is drawn by either one of two exhausters, each directly connected to a vertical engine. The exhauster delivers the gas to the supply main under a pressure of 1¾ lb., the speed of the engine being automatically controlled by the gas pressure through a diaphragm valve. The gas delivered is indicated and recorded by a venturi meter.

Air for combustion is drawn through the economizer by a steam blower mounted on the side of the generator. The mixture of steam and air is forced under pressure through the center pipe of the generator and out into the ash at the center tuyere cap *E*, or out through the tuyere arms *B* under the annular tuyere ring *F*. By actuating a lever, a drum and disk in the center pipe may be raised or lowered, causing the moist air to flow at the center or at the outside, as desired.

The amount of steam and consequently the quantity of air supplied to the generator is automatically controlled by a gasometer connecting with the top of the generator. Here a pressure slightly less than atmospheric is maintained. Any variation in pressure up or down influences the position of the gasometer and in turn increases or lessens the opening of the steam valve.

It is thus evident that the operation of the plant throughout is practically automatic. The air and steam supply to the generator is automatically controlled, as is the pressure and supply of gas to the supply main. The fire level and the discharge of ashes and clinker into the water seal is cared for by the mechanism connected to the grate.

It is estimated that the driving mechanism on each generator requires about ½ hp. The quality of the gas runs about 150 B.t.u. per cu.ft. While it is used for industrial purposes in the present plant, the gas can be generated with equal advantages for power purposes. The mechanical feature may be applied to old producers, saving the installation of additional generator capacity.

Effect of Rotor Resistance in an Induction Motor

By M. E. Wagner

SYNOPSIS—A discussion on how the resistance and inductance of the rotor circuit affect the starting torque of a squirrel-cage induction motor.

To understand the effect that the resistance of the rotor conductors has upon the starting torque of a squirrel-cage induction motor, it will be necessary to consider what takes place in the machine at the instant of starting.

In Fig. 1 two groups of windings A and B are shown at right angles to each other, which represent the stator winding of a two-phase induction motor. The small circles C represent the rotor conductors. The curves, Fig. 2, show the relation between the current waves of a two-phase circuit. Starting at a on the curves, it will be seen that wave A is at maximum when B is zero. Assume this to be the condition in Fig. 1, with the current flowing in A winding, as shown. This maximum current in winding A will set up a maximum flux in a direction indicated by the dotted lines and arrow-heads. As the current decreases in value, the flux will also decrease in value, which will induce an electromotive force in the rotor bars in a direction tending to set up a current to maintain the flux. Therefore if the rotor bars are short-circuited at each end by a ring R, a current will be set up in them in the same direction as that in the stator winding. This is indicated by the dots and crosses in the center of the circles, Fig. 1 (the dots represent direction toward the reader, the crosses direction down through the plane of the paper). The maximum change in the current and flux in phase A will be taking place at b on the curves (at this position the

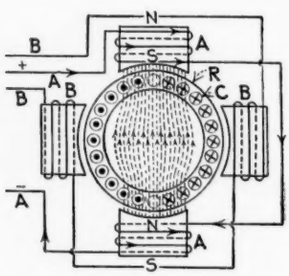


FIG. 1. CURRENT DECREASING IN STATOR

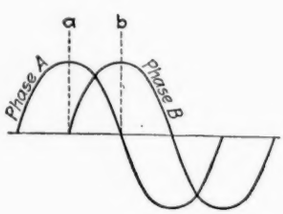


FIG. 2. TWO-PHASE CURRENT CURVES

current is changing from a positive to a negative direction), consequently the e.m.f. in the rotor bars will be at a maximum.

If it were possible to have a rotor with resistance only, the current in the rotor bars would be in step with the rotor e.m.f.; hence in Fig. 1, when the current in A winding is zero, the current in the rotor bars will be at a maximum. When the current in A winding is at zero, it is at a maximum in B. This condition is shown in Fig. 3. The current in the conductors under the B polepieces is in a direction to produce a torque in the direction indicated by the curved arrows; inasmuch as the current in the rotor and the flux in the stator are at a maximum, the torque will be at a maximum also.

On the other hand, if the rotor bars were without resistance, the current in them would be limited by inductance only and would be displaced 90 deg. from the rotor e.m.f.; hence a condition would exist similar to that in Fig. 4. It is obvious from the figure that no torque will be produced, as the current under one half

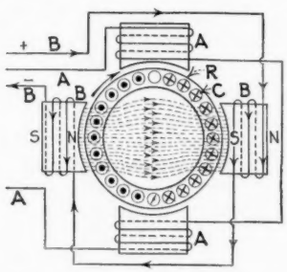


FIG. 3. EFFECT OF ROTOR RESISTANCE

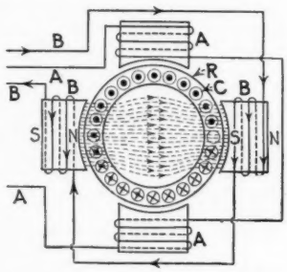


FIG. 4. EFFECT OF ROTOR INDUCTANCE

of the B polepieces is opposite to that under the other half. The two conditions illustrated in Figs. 3 and 4 are impossible to realize in practice, but they serve to illustrate the effect of resistance and inductance in the rotor circuit on the starting torque of an induction motor. In the practical machine there is always more or less resistance and inductance in the rotor circuit, depending upon the design of the machine. When the resistance is comparatively high, the starting torque is high; low resistance gives high inductance with a correspondingly low starting torque.

There is another important factor in the induction motor influenced by the resistance of the rotor—the efficiency. High-resistance rotors give high starting torque but low efficiency, while low-resistance rotors have a high efficiency and develop low starting torque. The ideal motor would be one that has high starting torque combined with high efficiency. The design of a squirrel-cage induction motor may be considered a compromise between these two factors.

Direct-Current Generators May Be Operated as Motors, and vice versa. The only essential difference is in the controlling apparatus. When used as a dynamo, the machine is provided with a high-resistance rheostat connected in series with the shunt-field windings, and when used as a motor it is provided with a low-resistance starting rheostat connected in series with the armature. When run as a dynamo, however, the speed must be somewhat higher than when run as a motor, if the voltage remains the same in both cases; this is due to the voltage drop through the armature circuit. To operate a compound-wound dynamo as a motor it is necessary to reverse the series-field connections; otherwise the series and shunt fields will oppose one another, resulting in a small starting torque and poor speed characteristics. A shunt-wound machine when running as a motor will run in the same direction as when driven as a dynamo, provided the connections remain unchanged. A series-wound machine when operated as a motor will run in the opposite direction to that in which it must be driven to operate as a dynamo.

Boiler-Room Cost Curves

By J. D. Morgan*

SYNOPSIS—A number of curves show how the different items, cost of coal, cost of water, evaporation rate, boiler rating, etc., influence the cost of steam.

It has generally been accepted that the unit cost for the boiler room should be the cost of evaporating 1,000 lb. of water from and at 212 deg. This is purely an arbitrary unit, but nevertheless it is the one best adapted to boiler-room costs.

The investment cost is a function that the operating engineer has no control over, but nevertheless it does, to a small degree, affect the total cost of steam. In the following discussion it will be assumed that, unless otherwise

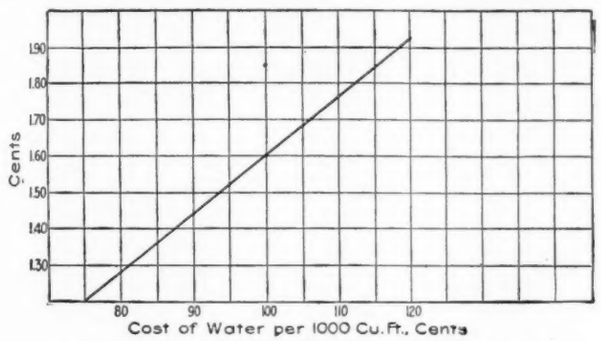


FIG. 1. WATER COST PER 1,000 LB. OF STEAM GENERATED BY THE BOILER

mentioned, the capacity factor of the boiler room is 100 per cent.—that is, that each boiler is being run at its normal rated output.

The cost of installing water-tube boilers is approximately $16.33 per horsepower with a full brick setting and about $18.16 for a steel casing. If stokers are desired, the investment will be increased approximately $7.67 per horsepower for Bayonne stokers and blowers, and $5.50

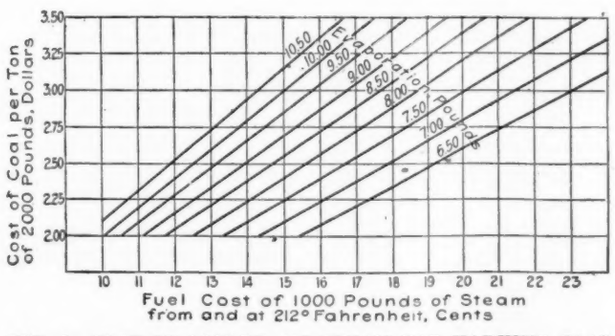


FIG. 2. COST OF 1,000 LB. OF STEAM FOR VARYING COAL COSTS AT VARIOUS EVAPORATION RATES

for Green stokers, $3.82 for Roney stokers, and $6.20 for Taylor stokers. To the installation cost of boilers and stokers must be added that of building, coal bunkers, feed-water heaters, feed-water pumps, stack, piping, etc. The cost of buildings per rated horsepower is approximately $8.50; coal bunkers, conveyors, etc., $11.60; feed-water pumps, $0.75; stack, brick, $2, steel, brick lined, $3; feed-water heaters, $0.75; flues, dampers, etc., $1.75; piping, $3. From these items it will be seen that the investment cost per boiler horsepower of a hand-fired plant will be about $44.70, while for a stoker plant the investment will be $51.

Into the cost of steam per 1,000 lb. the investment cost enters as a certain percentage to be charged per year; in other words, the interest, taxes and insurance will be about 10 per cent. of the total investment per year. If we assume this to be so, the investment cost per 1,000 lb. of steam will be 1.7c. for a hand-fired plant and 1.94c. for a stoker plant.

The depreciation cost is a very complex one because of the wide variation in the expected life of the various

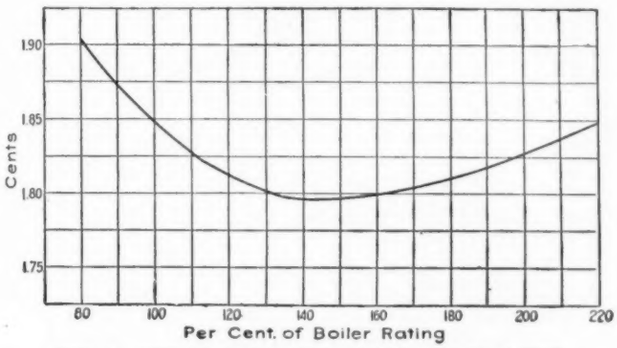


FIG. 3. TOTAL COST PER 1,000 LB. STEAM FOR DIFFERENT RATINGS

pieces of apparatus, but it is safe to assume that the useful life of the plant will be about 20 years with a final scrap value of 4 per cent. of the investment cost. This would make the depreciation cost per 1,000 lb. of steam about 0.092c. for a stoker-operated plant.

The obsolescence cost is one that must be assumed, for it is beyond the power of man to anticipate what changes invention will bring about. But in most plants where

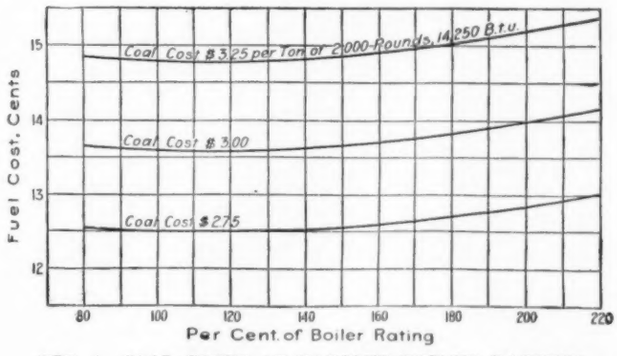


FIG. 4. COAL COSTS AT VARIOUS BOILER RATINGS AND COSTS PER TON

this cost is taken into consideration, it is done by decreasing the estimated life of the plant and thereby taking the obsolescence cost in the depreciation cost.

The maintenance cost is an important one, and accurate data should be kept on it. In a plant of 30,000 horsepower equipped with stokers the maintenance cost was found to be as follows: Boilers, furnaces and stokers, 1.08c. per 1,000 lb. of steam; buildings, etc., 0.127; pip-

*Engineer, Public Service Electric Co., Burlington, N. J., station.

ing, pumps, heaters, 0.182; total boiler-room maintenance, 1.317c. per 1,000 lb. of steam.

The labor cost depends on the size of boilers, whether stoker-operated, and also on the percentage of boiler rating. In a plant having fifty 600-hp. boilers, stoker-operated, the labor cost per 1,000 lb. of steam was found to

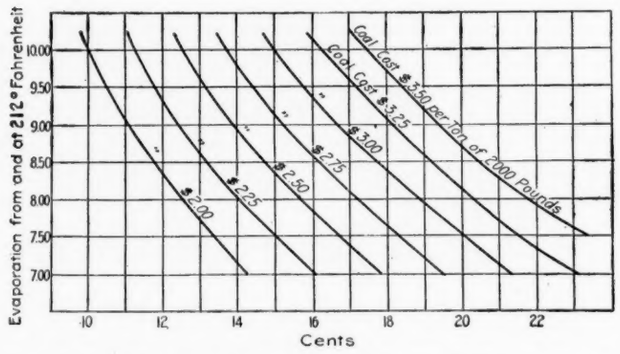


FIG. 5. COAL COST FOR VARIOUS EVAPORATION RATES

be 1.02c., while in a plant having six 600-hp. boilers, hand-fired, the labor cost was 2.82c. per 1,000 lb. of steam.

In many plants the purchase of feed water is a necessity, and the cost of water varies from $1.15 to $0.90 per 1,000 cu.ft. Assuming the price of water to be $1 per 1,000 cu.ft. and the radiation and leakage to be 2 lb. per 1,000 lb. of steam and no return condensate, the cost of water per 1,000 lb. of steam will be 1.603c. A curve, Fig. 1, is given showing the variation of the cost of water per 1,000 cu.ft. and for 1,000 lb. of steam.

The coal is by far the largest item entering into the cost of steam, and it has a wide range depending chiefly on the cost of coal and the efficiency of boiler. If we assume the cost of coal to be $3 per ton of 2,000 lb. and the evapora-

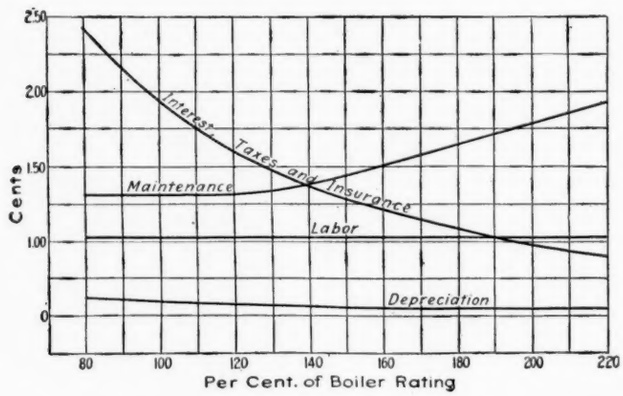


FIG. 6. VARIATION OF COST ITEMS WITH BOILER RATING

tion from and at 212 deg. F. to be 9 lb., the fuel cost per 1,000 lb. of steam will be 16.7c.

Figs. 2, 3, 4 and 5 show the effect of the cost of coal, evaporation and boiler rating on the fuel cost per 1,000 lb. of steam.

From the aforementioned costs it will be seen that the total cost of steam per 1,000 lb. will be 24.154c. for a hand-fired plant and will be 22.672c. for a stoker-operated plant.

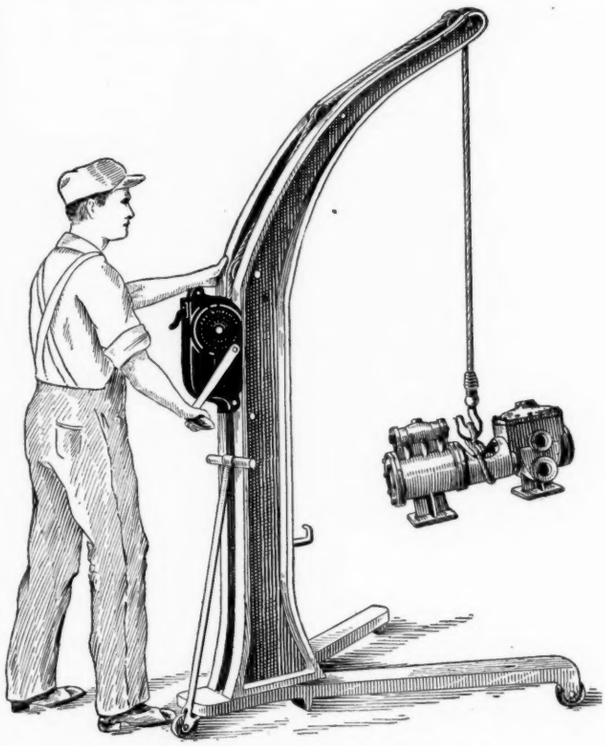
The percentage distribution of the cost of steam per 1,000 lb. is as follows:

Cost Item	Hand-Fired, per Cent.	Stoker-Operated, per Cent.
Investment	7.05	8.56
Depreciation	0.33	0.41
Maintenance	5.17	5.80
Labor	11.70	4.50
Water	6.64	7.07
Fuel	69.15	73.66

Fig. 6 shows the variation of the various cost items with the percentages of boiler rating.

Pullifter Portable Crane

Not every power plant is equipped with means for lifting heavy weights. In many of the smaller stations there is no provision for handling bearing caps, engine pistons or other parts. A device that should be handy for such



A CONVENIENT PORTABLE CRANE

work is the Pullifter portable crane, manufactured by the Giant Cable Hoist Co., Cleveland, Ohio. The appliance, illustrated herewith, consists of a single cable with a hook attached to one end. The body proper is attached to the crane frame and the cable is wound around the drum of the "pullifter." The hand crank of the device is operated by one man. The crane is capable of lifting 1,000 lb.

Steam Separators Are Used Primarily for entraping and separating from steam flowing in pipes, the entrained water, with means for drawing off the water so separated, and secondarily, as reservoirs to contain a body of steam to assist in overcoming harmful pulsation or sudden fluctuation in pressure. Their design and construction vary greatly, but the three principles involved are: (1) Centrifugal, or whirling, action of the mixture, by which the water is thrown outward by its weight and the centrifugal force against the sides of the shell and trickles downward out of the line of steam flow; (2) baffles or screens to intercept and retard the flow and velocity of the particles of moisture so as to permit them to fall into a receiver, not to again mingle with the steam; (3) sudden change in the direction of the steam's flow, so that the heavier particles, having a tendency to continue in the original direction, are thrown against the wall or other section of the separator and are drained away. Two or more of the foregoing principles may be combined in the same design.

Editorials

Analogies Between Electricity and Mechanics

The simplicity of the fundamental laws governing the flow of a direct current have a tendency to impress upon us the apparent complexity of the alternating-current circuit with its leading and lagging currents, its inductance, capacity, resistance and impedance, phase displacement between electromotive force and current, its true and apparent watts and power factor, and still more so since in recent years all synchronous machines and transformers are rated in kilovolt-amperes instead of kilowatts.

One thing that is too frequently overlooked is that most all phenomena that manifest themselves in alternating current will also be made manifest in direct current if given an opportunity. Those who are at all familiar with this subject know that if a direct-current circuit is continuously made and broken, some of the phenomena which are so characteristic of the alternating-current circuit immediately become manifest. There is also a direct similarity between certain fundamental laws of mechanics, and certain fundamental laws of electricity and magnetism. When the action of a force is such as to set a body in motion, energy is accumulated in the moving mass. In an analogous way, whenever an electromotive force causes a current to flow in an electric circuit, energy is stored up in the magnetic field produced by the current. If the body is allowed to slow down, mechanical energy is recovered; in the electric circuit if the current is decreased, energy is also recovered from the magnetic field. The analogy between an electric current and a mass in motion is more forcibly shown by certain fundamental equations for electricity and magnetism, being identical to that for a mass in motion.

A second analogy in mechanics is that when a spring is compressed, mechanical energy is converted into potential energy, or energy of position, and it is capable of doing work when the occasion presents itself. Likewise, when a condenser is connected to a source of electromotive force, electrical energy is stored in it in the form of potential energy and is capable of doing work when the occasion arises. Here again the fundamental equations are identical, therefore it would seem that we do not require new fundamental equations to express the laws of electricity and magnetism, but rather should adapt some of the already known laws of mechanics to the new medium.

Elsewhere in the columns of this issue is an article the object of which is to explain certain fundamental principles of alternating current by simple mechanical analogies. The manner in which these analogies are applied should greatly assist the reader to a better understanding of the fundamental ideas concerning alternating current and by a clearer conception of these fundamental principles he should find it easier to understand their application to alternating-current machinery.

Engineering Literature

An ambitious young stoker attendant in a power station sought in the second-hand bookstores literature to help him win a second-class engineer's license. He found a book dated some twelve years back that seemed to meet his requirements, being a compendium, in catechetical form, of certain boiler, engine and electrical lore presumed to cover an ordinary examination. The young man bought the book, studied it diligently and finally announced his intention of applying for a license. The engineer of the plant suggested a tentative test, and among other questions put the old one of how to reverse the direction of motion of a plain slide-valve engine. The aspirant for engineering honors replied that he would shift the eccentric exactly halfway around the shaft; whereat his mentor advised him to defer his interview with the examiners until he had learned more about valve motion. The young man insisted he was right and, to prove it, showed in his book where it plainly stated, "Shift the eccentric around one hundred and eighty degrees."

This incident leads to the consideration of books purporting to present the theory and practice of steam and electrical engineering, with the concomitant branches of heating and ventilation and refrigeration in proper guise to qualify a man for operating a power plant; of books that are printed to meet the ever-current demand for education on these subjects by oilers and firemen who aspire to the higher responsibilities of power-station work. Some of the older editions of such books—those brought out ten to twenty-five or thirty years ago, but which are still obtainable second-hand—contain equally as glaring misstatements as the one noted. In the later editions of those that are still extant, the errors have been expunged. But nevertheless, an examination of these, as well as the more recent books of like character, will leave the critical searcher much disappointed.

Operative steam engineering today is a distinct branch of practical science, and it would be equally as fatuous to attempt to squeeze a working knowledge of any other scientific practice—medicine and surgery, for example—into a single volume of ordinary size, as to expect to do that with a profitable knowledge of power-plant engineering. One might as consistently expect to be accounted a reliable physician by reason of having studied the family "doctor book" as to expect the incomplete knowledge obtainable from the class of engineering books here mentioned to qualify him as a first-class operator of steam plants.

These remarks are not aimed at those books of scientific formulas and data that have been accepted as standards of reference by the engineering profession—handbooks that are not offered by their authors and publishers as containing the concentrated essence of all that is to be known about practical engineering, but simply as compilations of staple items of information that every engineer has need of at various times and that, in their

entirety, no ordinary mortal could carry in his head. There is a distinction between volumes of this nature and the class of books printed under pretentious titles that stamp them in the view of inexperienced minds as veritable treasure vaults of engineering knowledge, but which actually contain only a smattering of the subjects they pretend to teach, along with some points of practice that a power plant worker of ordinary perception should acquire at first hand from actual experience and still others that can be fairly understood only by first preparing a foundation of technical science which the book does not pretend to supply.

No argument is needed in support of the assertion that a fairly comprehensive work on steam engineering and its allied branches cannot be published for the price at which some of the books claiming to cover the whole subject are sold. There are plenty of cheap books obtainable, but each presents but one of the many studies that go to complete an engineer's education. As a general proposition it can safely be said that the educational value of an instruction book on engineering, designed for private study, diminishes in exactly the same proportion as the number of subjects which the book undertakes to cover is increased. A volume that would bring a reasonable profit to the publisher when sold for, say, a dollar and a half or two dollars, and that would presume to supply instruction on the subjects of combustion, boiler design, the indicator, lubrication, pumps, refrigeration, and the several other topics that a complete treatise on engineering should embrace would manifestly be practically worthless simply because of the impossibility of giving more than the merest glimpse into each. A book limited to a single one of the subjects enumerated could, however, readily be sold for the price named and still be of sterling value in the information imparted.

The latter kind of books especially appeal to power-plant workers who feel they cannot lay out more than a dollar or two at any one time. In the purchase of such books they will generally find their money profitably spent, because they will get that thorough explanation of details which is the principal essential in fitting them for their work, and which it is folly to expect from a cursory skimming over of each subject.

Diesel Engine Tendencies

In the discussions which have been going on in our columns lately relative to two- and four-stroke-cycle Diesel engines it would appear, by the evidence submitted thus far, that the advocates of the latter type have the better of the argument. That there have been failures and successes with both types is evident, but the heat problems in the two-stroke-cycle engine are such as to call for designs and workmanship that have been met successfully by only a few firms. In fact, several firms that were building both types are now confining their efforts entirely to the four-stroke cycle. It would be presumptuous, however, to accept this as proof of the doom of the two-stroke-cycle engine. Undoubtedly many of its difficulties will in time be overcome provided there is the proper incentive to devote the necessary research work, and those firms which are devoting their best efforts toward this end should be encouraged. For the present, however, the advantage for certain kinds of service appears to be with the four-stroke cycle.

The outlook for the Diesel in this country is especially promising for small central stations and factories in the South and Southwest, as well as in the marine field. A large number of installations were made during the last year, and it is estimated that orders now on hand exceed thirty-five thousand horsepower in land engines of the regular Diesel type alone. In the marine field it is significant that three of our largest ship-building firms have recently taken out licenses to build Diesels.

Graphical Records

Formerly it was only the technically trained man that used and understood graphical presentations, but with the extension of engineering methods to business operations, they are now becoming indispensable to executives, and business men in general are learning to make more or less use of them. Indeed, to cite an extreme case, a certain Sunday school within the boundaries of New York regularly plots the attendance and offerings graphically and the children are able to interpret them readily.

The large power plants have long made use of such methods, but one still finds many small plants that have yet to acquire the habit. This is particularly true where the engineers are of the old school, so to speak. They prefer to ponder over columns of figures rather than size up the situation with the aid of a set of curves. It is probably not so much lack of comprehension of graphical methods as it is inability to overcome a sort of mental inertia in the old way of doing things.

Of course there are certain data which preferably should be presented in tabular form, but when the performance of a plant is to be compared month by month or year by year, or the operating characteristics of a piece of apparatus are to be studied, curves are indispensable. Moreover, they often show up the unexpected and thereby lead to investigations and improvements in operation along lines that otherwise would not be thought of. Just as a single picture may tell a story better than pages of text, a set of curves will often tell more than pages of figures.

Fire Commissioner Adamson of New York City advises that his department will not examine operators of refrigeration plants and charge them five dollars each, as he contemplated, but will recognize licenses to operate such plants when issued by any city department. We could not believe that the Commissioner would approve such a plan when the police department already examines and licenses such operators.

The anthracite operators have been busy lately. Besides tinkering with prices, they will immediately change the anthracite sizes without renaming them, with one exception. The plan is to alter the standard of preparation of the sizes by introducing thirty to forty per cent. of the next smaller size. Pea coal will have thirty to forty per cent. buckwheat; buckwheat will carry thirty to forty per cent. rice. We are to have a "boiler" coal consisting of rice and barley. At least one large coal company intends to increase the prices ten cents each month until an increase of forty cents per ton is reached by September first. Looks as though some folks may have to change their grates and make a new standard for the cost of steam per thousand pounds.

Correspondence

Slip of Riveted Joints

In *Power* for May 2 Brown was told why welded joints for boilers were not welcomed by boiler inspectors—for the reason that when the weld was once made, there was no means of inspection which would disclose faulty work. The welded joint was a matter in which the "personal equation" of the workman was uppermost. Welds, however, made by first-class, careful workmen were satisfactory. In a like manner may be presented the subject of riveted joints designed to withstand slippage. In this case, also, satisfactory inspection could not be made unless the inspector watched the driving of each rivet.

Relative to the question of the German method of design of pressure vessels, considering the slippage of the joints, brought up by Mr. Goder in the May 2 issue of *Power:* Professor Bach's conclusions are as follows: That in cooling, the rivet shrinks away from the hole in the plate; that failure of the joint will occur (as far as all practical considerations are concerned) by loss of tightness; that the percentage of the ultimate failure of the joint at which slippage occurs is directly in proportion to the square of the diameter of the rivet, and is increased by calking both edges and rivet heads, and by holding the rivet in the machine until same is cool. Finally he reports that slippage was found by him to occur at 25 to 35 per cent. of the ultimate strength of the plate.

From the standpoint of American practice we have the following: The lap joint is distorted slightly when under pressure, making the rivet become oblique in the hole, and the frictional resistance of the joint is a questionable quantity. In all joints, there occurs some bending of the rivets, resulting in concentrated crushing stress on the plates. Besides, as already mentioned, workmanship may be poor, and finally we have little or no knowledge of the distribution of the stresses. We only know to a satisfactory degree what the ultimate strength of the joint is, and as a rule this has been found to exceed the calculated value.

In designing joints in America, the general proceeding after selecting the type of joint desired, is as follows:

Write the method and resistance to failure for all possible ways the joint may fail. Select a diameter of rivet taken as some function of the thickness of plate, so that in making the hole the plate will fail by shearing and not by crushing. The diameter of rivet as selected by this method usually means that the rivet will fail by shearing, and if so, the resistance of the rivet to shear is equated to the tearing of the plate between rivet holes, thereby securing the pitch of the rivets which will give a joint as strong along the line of rivets as the rivets are to shear. The joint must be tested by calculation for failure at each point, using the selected diameter of rivet and pitch, and the joint must be found to be stronger from the outside to the inside.

In this calculation, friction is not considered, nor is the matter of the "grooved specimen." The ultimate strength of the joint only is given attention, and the joint is made nearly as strong in one method of failure as in another. Following our usual method in machine design, a factor of safety is taken—5½ or 6—so that the fiber stress developed will be well within the elastic limit even under test conditions of 50 per cent. excess pressure. The limiting value of the pitch is that which will allow a steam-tight joint. It has been found by laboratory experiment that steam leakage will not occur for a deflection of 0.00035 in. or less at the center of the pitch length. It is then necessary only to make sure by calculation, or otherwise, that the pitch chosen will not allow a greater deflection than this value at the test pressure.

Finally, it may be said that our method of designing riveted joints is rational. Each possible method of failure is considered and tested for calculation. The boiler joint is open to inspection at any time. There is no factor of ignorance or of carelessness to be worried about. As regards slippage, Bach's tests show that this occurs at about three-tenths of the ultimate strength, a value much above the allowable operating pressure. It would therefore seem that Mr. Goder's remarks are uncalled for, when he disparagingly compares American with German practice.

H. J. MACINTIRE.

Seattle, Wash.

Mr. Williams on Illuminating Liberty Statue

It is matter of regret that you should have misunderstood my views concerning the admirable plan of permanently lighting the Statue of Liberty, as expressed in your issue of the 13th instant. Ever since the illumination of the statue in connection with the Hudson-Fulton Celebration, those of us who have been identified with public illuminations in this city have been most anxious to secure its permanent equipment, either for continuous use or, if this would not be permitted because of interference with navigation, for convenient use on fete and other special occasions.

In fact, the thought of the Mayor's Committee on Illuminations for the Fourth of July last year, of which I had the honor of being chairman, was to make a permanent installation of this nature as soon as the funds could be secured. It was purposed to ask an added appropriation this year until we learned of the plan of the New York *World,* which, in my judgment, has a prior and very proper claim, in view of the efforts of that journal, so successfully accomplished, to provide a fitting base for this splendid gift of the French Nation.

My very natural desire for this illumination has nothing to do with the question of central-station or private-plant service. The illumination itself and that for which the illumination would stand are the great objectives—the source of the energy being entirely secondary, in that of the two sources available it should be the one which is the more economical and efficient.

It is not always possible, I fully realize, to quote or interpret one's views with exactness. But in a matter

such as this, involving a great National project on the one hand and ordinary common sense, if not one's patriotism, on the other, it would be unfortunate to have a misunderstanding remain in the minds of your readers, such as might follow an uncorrected interpretation of the views recently expressed at Chicago. Entirely irrespective of the source from which the energy is derived, the project should have the unanimous support of all interested in the electrical industry of the country, and those who favor making this great statue a beacon of greeting and welcome, by night as well as by day, to those returning to their own country and, perhaps even more, to those who first come to our shores, either as visitors or as prospective home makers.

While I have not in mind exactly what was said at Chicago, my views were expressed with the understanding that a private electrical plant had been planned for Bedloe's Island, without communicating with or obtaining the prices of the neighboring electric light companies. My remarks were also based upon the studies we had made in connection with our plans to permanently light the statue, showing that the cost of the plant would be in excess of the cost of central-station service, if a cable could be extended from the shore. This would seem axiomatic, when remembering that an engineering organization would have to live on the Island simply for the purpose of operating a plant of something less than fifty kilowatts.

What was said at the meeting is to be considered with the understanding that those in charge of the plans had failed to do the very thing recommended by your editorial, namely, study the question from both standpoints and determine on economic grounds wholly which of the two methods of service would be preferable.

New York. ARTHUR WILLIAMS.

[Following is a report of Mr. Williams' remarks at the National Electric-Light Association Convention.—Editor.]

While heartily subscribing to the views expressed by Mr. Doherty, may I call attention to the fact that the Statue of Liberty lies in the territory supplied by either the Brooklyn Edison Co. or the Public Service Corporation of New Jersey or the New York Edison and the United Electric Light and Power companies and naturally all of the companies are greatly interested in this enterprise. The New York *World* is carrying on an active campaign for the illumination of the statue, in which we are all very anxious to take a part. I think, however, that it is a mistaken policy on the part of some of our prominent engineers to favor the installation of a private plant at the statue. The several companies mentioned have been giving the subject a great deal of attention during the past two or three years and at least one of them, in my judgment, will be prepared to carry a cable to the island, without expense to the Government, believing that to be the most economical and efficient manner of securing electric energy. I think it would be undesirable to place a private plant on Bedloe's Island, both from the standpoint of economy and good service.

There has been a question as to having a bright spot in New York Harbor that would in any way dazzle the eyes of pilots taking vessels through the harbor and endanger navigation. This is one of the matters which, of course, must be considered in the plan of illumination.

Then again, I have no thought of "putting a fly in the butter," but I seriously urge against any action on the part of the prominent engineers of the country to install a private plant at the Statue of Liberty, owing to the availability of central-station service and for the reasons which I have given, based upon the relative economy and the character of service. If any plans have been approved for a plant, I think they should be revised.

Interesting Belt-Cutting Kink

In spite of all the belt kinks I have read and the number of times belt men have been cautioned to "cut the belt square" before lacing, here is a good one that insures straight running even though the cut is not made square. In fact, a straight-edge or steel square is not needed at all for jointing narrow belts. J. C. Conn is

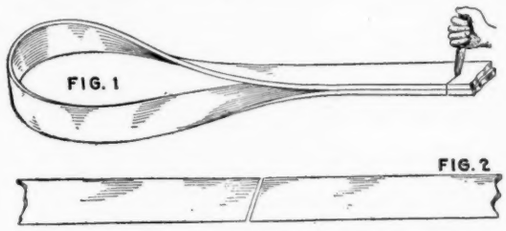


FIG. 1. SHOWS HOW THE BELT IS FOLDED, FIG. 2 HOW IT MATCHES

the discoverer of the method, and he has given me permission to give it to the belting world.

The sketches show the method plainly—Fig. 1 how the belt is laid for cutting and Fig. 2 how the ends match. Match the two ends, one on top of the other as shown, with both smooth sides either up or down and the sides perfectly even. Then cut both together along a straight line. If cut square, at 45 deg. or any other angle, the joint will be a perfect fit.

In case of double or triple belts, where both sides are smooth, place the "outside" of the belt either up or down. The belt must be twisted so that *the same side is on top* at the point of cutting. The reason is evident.

New York City. W. F. SCHAPHORST.

University Extension

I was mighty glad to find out that there are several colleges and universities of recognized standing in this country that have developed a system of correspondence instruction. Many of these institutions provide correspondence courses on engineering subjects, and under certain conditions credit is allowed toward a degree for work satisfactorily completed. It is not possible to do all the work necessary to obtain a degree, by correspondence, or, as the school bulletins put it *in absentia;* part of the course must be taken "in residence." The amount which may be taken by correspondence varies in the several institutions.

There are men who have no desire for a college training, and of course they will take no interest in the subject, but others who crave a training of this kind but are unable to realize their ambition will be interested. Some would be able to attend a university for one or two terms, but a four- or five-year course would be impossible. Anyone who desires to know more about this matter should write to the Bureau of Education, Department of the Interior, Washington, D. C., asking for a copy of the bulletin entitled "University Extension in the United States" and such other literature as it may have containing informa-

tion concerning correspondence instruction offered by state and other universities and colleges. From the bulletins may be obtained the names and locations of these institutions, together with a general outline of the extent to which each has developed a system of correspondence instruction, cost of tuition and other necessary information. Details may then be obtained from the extension division of the individual institutions.

One of the first questions likely to be asked is, "How much will it cost to take a course with one of these colleges by correspondence?" One university with which I exchanged correspondence has a charge of $10 a year for residents of the state and $15 for nonresidents. For this amount the student is entitled to tuition for a calendar year, and he may carry two courses at a time. All necessary textbooks, etc., must be procured by the student, who also pays postage on lessons one way. The fee may be paid in monthly installments of $5 when the student finds it necessary. Some have a charge slightly higher than the one mentioned, and some charge less. One thing is certain—there can be no profit in it for the schools. The bulletin of the university mentioned states that "The motive is public service, and profit is entirely eliminated."

It seems to me that this has opened up a grand opportunity for a good many men—young and some not so young—who have heretofore been denied a college training, but who have the desire for one and ambition and energy enough to work for it. H. G. Gibson.

Washington, D. C.

Just Fooling

The letter on the danger of "Just Fooling" by Arthur D. Palmer on page 780 in the issue of May 30 is worthy of emphasis. One of the most unpleasant and dangerous men about power plants and machinery is the so-called practical joker and he should not be tolerated, nor the man who is continually "starting a rough house" who is no better.

I remember seeing two men racing about a power house where there were three belted dynamos, driven by gas engines. The belts were not protected in any way, the floor was uneven and greasy and the light in the room was very poor. They were taking the chances of falling onto a belt or against moving machinery all for an orange which one had and the other wanted.

A group of men in a foundry had a habit of "initiating" every new man by squirting gasoline on his clothes and lighting it. They tried it on an electrician who came to repair a traveling crane, but realizing the danger he promptly resented the attempt and the men desisted, but when the electrician got up on the crane the men annoyed him by throwing lumps of sand and pieces of iron. He watched carefully until he saw one of the men throw, and picked up a one-inch nut and threw it as hard as he could, but fortunately he missed the man. The fun stopped at once for the electrician had the best strategic position and one cannot blame him for losing his temper as he was attending to his own work and did not care for the horseplay. Yet it would have been an unpleasant incident for all concerned if he had hit the man with the heavy iron nut. Men who indulge in such horseplay as this "initiation" ought to be cautioned at the first offense and summarily discharged for the second offense.

One big powerful fellow in the testing crew of a gas engine company started the 60-horsepower motors easily and was proud that he could do so. At a favorable opportunity a smaller man who had more trouble in starting the engines stuffed a piece of waste into the air intake pipe of the engine on which the larger man was working. In his efforts to start the engine he worked so hard that he was nearly exhausted. While he was away for a drink of water the joker then removed the waste after which the engine started easily. Some of the men thought it a huge joke but it was a decidedly unfair trick and cost the company several dollars in time lost.

At the same plant gas engines belted to dynamos were used to furnish power for the shop. One noon some joker substituted water for gasoline in the can used for priming and the whole shop was idle for a time before the trouble was discovered. That little joke cost the company, in time lost, twenty to twenty-five dollars.

The engineer in a steam plant often cleaned his pipe with live steam from the gage cock. The old sweeper saw it done and asked permission to clean his pipe also. He opened the bottom cock too quickly and was severely scalded by the hot water. The engineer might easily have stopped him but thought, "It was fun to see the old man jump."

Men ought to realize that around power plants and machinery there is always danger of accidents and injury and the man who persists in trying practical jokes is criminally careless of his own and the safety of others.

Charles City, Iowa. C. V. Hull.

A Large Steel Smoke-Stack

Facts and figures concerning two large steel stacks recently built for the Northwest Station of the Commonwealth Company that may be of interest are as follows:

Each stack is 286 ft. above the ground and 183 ft. above the roof of the boiler house. Their internal diameter is 18 ft. 4 in. Four openings in the base are furnished for flue connections, each opening being 17 ft. high and 11 ft. wide. The completed stacks and flues required 376 tons of steel, 88,900 rivets, 50,000 firebricks, 48,000 stack blocks, 1,400 book tile, 700 bags of cement, 75 cu.yd. of sand and 100 barrels of lime. Of the 88,900 rivets placed 700 were rejected and replaced, an extremely low percentage. R. K. Long.

Chicago, Ill.

Deportment of Lamps Under Excess Voltage

In testing lighting circuits two 110-volt lamps are frequently placed in series with each other, with cord connections so arranged that either one or both lamps may be placed across a circuit. It sometimes happens that after testing a 110-volt circuit with one lamp cut out, a lineman will make a test on a 220-volt circuit without noticing that one of the lamps is cut out. Upon connecting a 110-volt lamp of the carbon-filament type across 220 volts, the lamp will usually be shattered.

Now the tension of the residual air in an exhausted lamp bulb is only about 1/3000 atmosphere, and it does not appear that any possible elevation of temperature could make the air pressure inside of the bulb equal to the air pressure on the outside.

The question then arises: What is it that shatters the bulb? Furthermore, is the loud report that is heard the result of explosion from within, or is it to be referred to atmospheric pressure closing in and filling a vacuum after the walls of the bulb have failed?

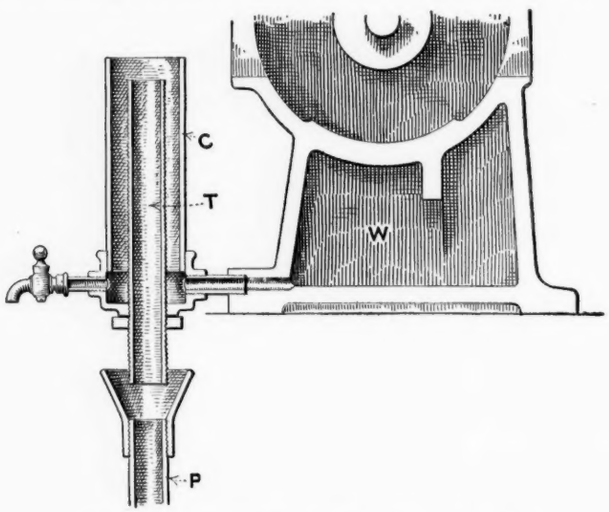
This peculiar lamp deportment has repeatedly come under the writer's personal observation, and neither technical nor practical electrical men who have been approached on the subject have been able to furnish a logical explanation. T. H. REARDON.

North Adams, Mass.

Care of Oil Separators

Certain high-speed engines employ the "splash" system for lubricating the crank, crosshead and main bearings. Engineers differ as to the advantages of this form of lubrication, for it has its merits as well as its failings, but, be that as it may, we have it with us, and the proper thing to do is to make it perform its best.

A necessary adjunct of this system (in some makes of engines) is the oil separator, designed to automatically dispose of any water that may accumulate from the piston rod stuffing-box and to prevent the oil going with it. The



WATER OVERFLOW FOR SPLASH OILER

illustration is intended to show the essential features of an oil and water separator.

The tube *T*, which is threaded its full length, should be screwed well up into the container *C*. The well *W* should be filled with water to within about an inch of the top, after which oil should be put in the crank chamber until the surface of the oil is about level with the bottom of the crank disk. When the engine is up to speed, the tube *T* should be lowered until its upper end is about on a level with the surface of the water in the well *W* and locked with the nut provided to hold it in place. After the right height for the tube has been determined, it should not be necessary to change it. In operation any water entering the well *W* will raise the level of the water above the top of the tube *T* and the excess will flow into the waste pipe *P*. Oil will of course float on the top of the water, which will prevent its escape.

Pieces of waste, dust, bits of packing and cylinder oil that ooze out around the piston rod will in time clog up the passageway between the well and separator. This will make the device inoperative, and the churning action of the crank will soon emulsify the oil and water, making it unfit for use. When this happens, an inexperienced operator is likely to conclude that the tube *T* needs resetting and make himself a lot of unnecessary trouble by changing it. A good way to clean the device is to drain the water and oil through the cock provided for the purpose and then flush it with gasoline or kerosene. Where there are several separators to look after, it is well to keep a can of this oil on hand, as it may be used over and over by allowing the sediment to settle out and pouring off the oil.

A piece of ordinary wire fly-screen laid under the piston rod stuffing-box nut, if kept clean, will prevent foreign substance from getting into the oil well.

The lower end of the tube *T* should not be rigidly connected to the drain pipe, but should empty into a funnel as shown, so that the lower end of the tube is exposed to view. As only a small quantity of water flows, it is difficult to tell by looking into the top whether any water is passing over the edge of the tube, but when the lower end of the tube is exposed any overflow can easily be seen. H. G. GIBSON.

Washington, D. C.

Alcohol as Fuel

Your editorial in the June 6 issue on "Alcohol as Fuel" brings to mind the removal of the high tax from denatured alcohol some years ago, with a view to encouraging its use for power, and the lack of public response to this concession. Whether or not this has been because it is more profitable to make alcohol in the form of whisky, the question of industrial alcohol bears an interesting relation to that of liquor.

If a national prohibition law should be enacted, the existing distilleries might be utilized for making power fluid. This would tend to prevent throwing them and their workmen out of business, which is commonly raised as an objection to stoppage of the liquor traffic. Moreover, the same would apply to the farmers who raise corn or other produce for their consumption. It is even likely that business of both classes would be greatly increased after industrial alcohol had once obtained a fair start, to say nothing of the benefit to the public after the liquid had been brought down to a normal price resulting from extensive manufacture. B. U. FAY.

New York City.

Crank-Disk Boring Bar

The following is a description of a boring bar that was rigged up to rebore the hole in a crank disk before putting in a new crankpin in an 1,800-hp. tandem-compound engine at the Union Lumber Co.'s plant, at Ft. Bragg, Calif. The crankpin developed a slight knock, and upon inspection it was found loose. It was shimmed, the key driven "home," and plans were immediately made for putting in a new pin. The first problem was to rebore the hole true, and the idea here described was carried out. This may be old, but it was original with me.

First a diagram of the tapered crankpin hole was drawn, as shown in Fig. 1 by *A*, *B*, *C* and *D*. A piece of shaft selected to serve as a boring bar happened

to be 4 in. diameter and of suitable length. The bar was laid off as in Fig. 1, parallel with the bore of one side of the tapered hole. The centers were then laid off where the center line *EF* intercepted the ends of the bar *J*, by scratching parallel lines across each end through the center of the bar with a surface gage and then laying off the centers from the side of the bar on these lines, at distances corresponding with *HF* on one end and *EG* on the other.

The bar was next put in a lathe upon the centers just described and a spindle turned 1½ in. diameter on each end, making one end long enough to receive a driven

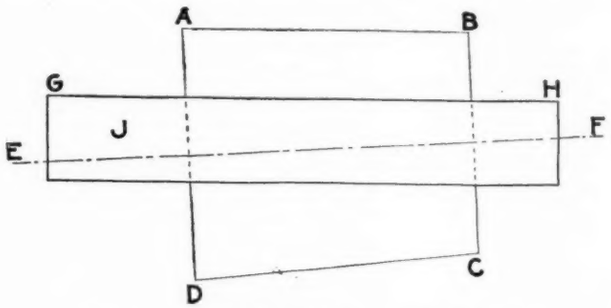


FIG. 1. DIAGRAM OF THE TAPERED HOLE

wheel or gear. A sliding collar with a tool mounted was fitted as shown in Fig. 2. A keyway *A* was cut in the bar and a small standard-thread lead screw *I* fitted in it, which worked through a hollow threaded key attached to the collar. This completed the bar.

As the collar *C* slides from *A* to *B*, Fig 2, it bores a smaller hole, because the bar is more off center at the end *A* than it is at the end *B*. Care must be exercised to see that the tool point is on the side of the bar where the most throw is; otherwise the taper will not correspond with the diagram used in laying off the centers.

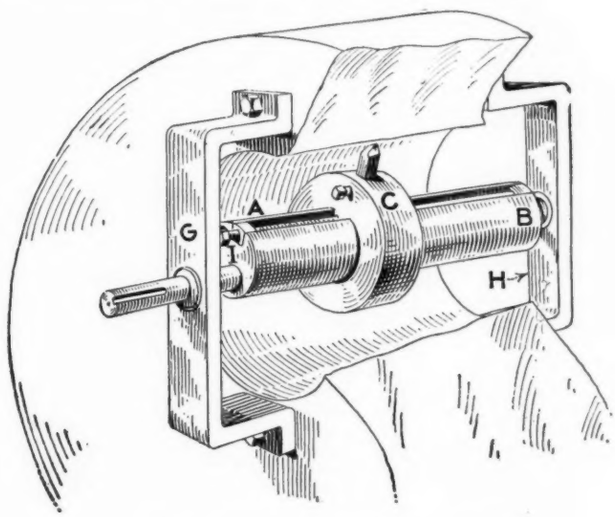


FIG. 2. BORING BAR IN POSITION

Forgings were next made of 1x4-in. soft steel to correspond with *G* and *H*, and were bolted to the engine disk to serve as bearings to the spindles of the bar, brass bushings being fitted for the spindles. These brackets were clamped to the disk so they could be moved until the bar was centered and square. Capscrews were put in to hold them solid.

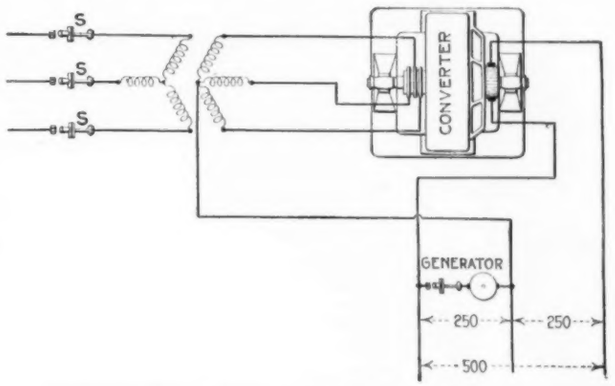
The bar was driven with a gear and pinion taken from the lead screw of a 24-in. lathe. The pinion shaft was belted to a small motor. This bar does a perfect job if it is carefully made and runs at the proper speed. The hole in the disk was 12 in. on the large end, 11⅝ in. on the small end and 14 in. long.

This plant is 150 mi. from the nearest machine shop, and it was necessary to get out of the crankpin trouble without shutting down, as the electric-light plant that supplies five towns is dependent on the sawmill for fuel. To supply this necessitates running the mill day and night, as has been done for 12 yr., and shutting down is out of the question. Some engineers make a reamer that follows the old hole and can never be held square.

Ft. Bragg, Calif. E. H. PERCY.

Rotary Converter Runs as a Potential Transformer

While testing an oil engine recently on the test block, it was desired to run it on a shop load. The shop was equipped with a three-wire grounded circuit, the power being furnished by a rotary converter. The voltage across the line was 250 and 500 volts, while the generator, which was direct-connected to the engine, was of 250 volts.



CONNECTIONS BETWEEN CONVERTER AND GENERATOR

It would of course have been possible to place the generator across in parallel with one side of the shop; that is, across either the neutral and the positive or the neutral and the negative. In fact, we did run in this manner for a considerable time later on.

We decided to experiment a little, however, and as the power furnished by the converter was just about the rated capacity of the engine, our problem was to find a way of running the converter with the 250-volt generator and at the same time provide both 250- and 500-volt power in the three-wire shop circuit. The way the problem was actually solved is shown in the accompanying sketch.

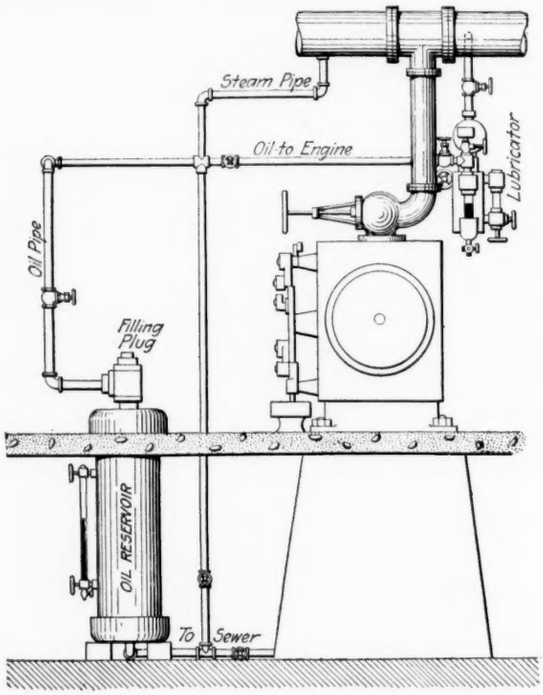
The oil engine was started and the generator voltage brought up to that of the line with the converter running. The generator was then put in parallel with one side of the line and its voltage regulated so that it was carrying practically no load. The alternating-current primary side of the line to the converter was opened at points *SSS*, and the converter continued to run, producing 500 volts across the positive and negative sides of the line and 250 volts between the neutral and either outside wire.

The power required was somewhat greater than had been figured, causing an overload on the engine, so that at the end of about half an hour we discontinued the use of this method. The converter seemed to run as well as ever under the new conditions, however, and showed no bad effects at the end of the half-hour run.

Erie, Penn. THEODORE M. ROBIE.

Cylinder-Oiling Device

Hugh G. Boutell's cylinder-oiling device, described on page 372 of the Mar. 14 issue, is a good one, but all plants do not have compressed air. I have erected a somewhat similar apparatus for sight-feed cups on engines and



OIL SYSTEM USING STEAM PRESSURE

pumps, and in place of air pressure I used a steam pipe from the steam main to the bottom of the oil reservoir, as shown in the sketch. The reservoir is made of 12-in. steam pipe. This gives a continuous oil pressure at the sight feed, and there is no need to empty the lubricators, as no water can get to them. J. C. SCHENCK.

New York City.

Pistons Used in Another Compressor

A horizontal double-acting ammonia compressor, ammonia cylinder 18x32 in., had been in use about seven years when last June one of the discharge-valve stems broke in two places, dropping into the cylinder. I was only a few steps from the machine at the time, but before I could close the throttle the damage had been done. The head was cracked along the bottom edge. On removing the head, I discovered that the piston rod was also badly bent.

Being our rush season, we did not have time to send to the factory for a new head and to have the rod straightened. The company having another plant only 350 miles away, it was decided to remove the head, piston and piston rod from a spare machine there and use the parts in the broken compressor. By doing this the plant was shut down only 36 hr.

Diagrams from the broken compressor after being fitted with the piston that had been used in another machine for six years showed excellent results. Fortunately we closed the suction and discharge valves before we had lost an appreciable quantity of ammonia, thanks to the helmet. JACOB STUMPF.

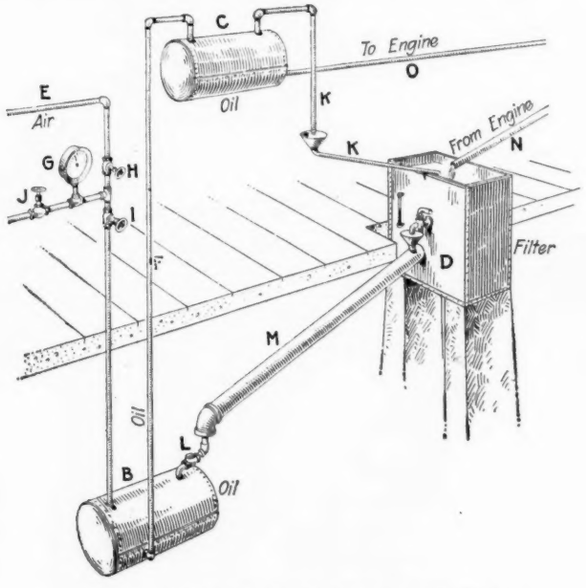
Las Vegas, Nev.

Gravity Oiling System

For some years we have been using the gravity system in oiling a 28x54x54-in. compound Corliss engine delivering the oil to the upper tank by a small steam pump. I have recently substituted compressed air to take the place of the pump, with gratifying results.

Referring to the illustration, below the engine-room concrete floor there is a basement where the oil tank *B* is placed; *C* is the upper tank and *D* is the filter; *E* is an air pipe and *F* is the oil pipe connecting the two tanks. A pressure gage is placed at *G*, and the air valve *H* is to control the pressure. An extra valve *I* is to trap the water, should any collect, and through which it is to be blown to clean out the pipe. The valve *J* is used to relieve the pressure from the lower tank when the upper one has been filled. The overflow pipes *KK* to the filter indicate by the appearance of oil or air at the funnel whether the upper tank *C* is full or whether there is not enough oil to fill it. A check valve *L* closes communication between the lower tank and the filter while the air is on. A globe valve may be used here, but it is not as good.

A 2-in. pipe *M* connects the lower tank with the filter discharge and is large enough to retain the oil that is



PIPING OF A GRAVITY-OILING SYSTEM

passing through the filter while the air pressure is on, or the filter outlet may be closed during this time. The pipe or pipes *N* conduct oil from the engine bearings to the filter, and the pipe *O* leads to the engine bearings. The time occupied in transferring the oil to upper tank is but a few minutes. J. J. NEWBAKER.

Steelton, Penn.

Inquiries of General Interest

Flywheel Pumps Require Heavy Cylinder Castings—Why must the castings of the water end of a flywheel pump be heavier than for a direct-acting pump that discharges against the same pressure? J. R.

With a flywheel pump the cylinder casting must be heavier for greater strength to resist shocks. Any backlash from lost motion in the crankshaft bearings or connecting-rod pins causes pounding of the water piston in suddenly overcoming the inertia of the water at the beginning of each discharge stroke and gives rise to shock and excessive pressure. In a direct-acting pump no such pounding from lost motion is present. The piston overcomes the inertia more gradually, and as the parts are less subjected to shocks, the cylinder may be of lighter construction than for a flywheel pump.

Locating Vacuum Line on Indicator Diagram—In indicating a condensing engine how is the line of perfect vacuum traced on the diagram? R. B. A.

After taking the diagram, close the indicator cock and again bring the pencil to the paper for tracing the atmospheric line. Remove the card from the indicator and, at the same scale as the scale of the spring with which the diagram was made, locate a point on the card below the atmospheric line at a distance corresponding to the pressure of the atmosphere. A straight line drawn through this point parallel with the atmospheric line will be the absolute zero, or vacuum, line of the diagram.

Number of Expansions, or Ratio of Expansion—What is meant by the number of expansions of steam in a cylinder? R. C.

The number of expansions, or "ratio of expansion," is the number of times the initial volume or space occupied by the steam would have to be taken to make the same volume as the space filled by the steam after it has become expanded. In considering the number of expansions in a steam engine, the initial volume is understood to consist of the clearance volume plus the volume of piston displacement at cutoff and the final volume is usually understood to be the clearance volume plus the volume displaced by the piston in making a complete stroke.

Changes Required by Addition of Lap—If lap is added to the steam valve of an engine, what other changes must be made in the valve gear? J. J. D.

The addition of lap causes the valve to open later, to uncover less port opening and to close earlier in the stroke of the piston. To preserve the same lead, the addition of lap would require the eccentric to be advanced around the shaft in the direction of rotation, and to obtain the same maximum port opening, it would be necessary to increase the travel of the valve by increasing the throw of the eccentric or by adjusting the relative length of the rocker arms.

Relative Power of Engines—Which will develop more power for the same m.e.p., a 12x24-in. engine running 200 r.p.m. or one that is 17x24 in. running 100 r.p.m.? A. H. A.

With the same m.e.p. the relative power developed will be directly as the piston area and as the piston speed. The areas of pistons will be as the squares of their diameters, and the piston speeds will be as the revolutions per minute; hence the power developed by the 12-in. engine will be to that developed by the 17-in. engine as $(12^2 \times 200)$ to $(17^2 \times 100)$, or 28,800 to 28,900. That is, the 12-in. engine will develop $(28{,}800 \times 100) \div 28{,}900 = 99.6$ per cent., or practically the same power as the 17-in. engine.

Friction Diagrams from Condensing Engine—For indicating the friction load of a cross-compound condensing engine, how is work done in the low-pressure cylinder to be accounted for if there is no receiver pressure and a vacuum of 26 in.? F. P. K.

A correct compound pressure-and-vacuum gage on the receiver undoubtedly would indicate considerable pressure above vacuum, and some pressure above 26 in. vacuum would be shown on indicator diagrams taken from the low-pressure cylinder. The m.e.p. of the low-pressure cylinder is to be applied in computation of the power developed, regardless of whether the initial pressure is above or below the pressure of the atmosphere.

Lap of Steam Valves of Duplex Pump—Why are the steam valves of a duplex pump made with little or no lap? J. J. D.

The steam valves are given only enough lap to cover the irregularities of the edges of the ports, so the steam may follow for the full stroke of the pistons and because any additional lap would increase the probability of having the valves stop in positions where all ports would be covered and from which positions it would be impossible to start the pump. By giving little or no lap, the chance of having all ports covered at the same time is practically eliminated, for there is only one point in the stroke of each piston when the valve which it controls has the ports covered and, to prevent the pump from starting, both pistons would need to stand at their respective dead centers.

Increasing Speed of Throttle-Governed Engine—What changes should be made in the adjustment of a throttling governor to increase the speed of the engine on which it is employed? W. M.

In some throttling governors, the valve stem or its connections may be adjusted for admitting more or less steam as desired for a given position of the governor balls, and the engine speed can be increased within the limits obtainable by such an adjustment. Most throttling governors are provided with springs or weights which may be adjusted for varying a resistance offered to the centrifugal effort of the governor balls. By increasing that resistance, the engine and governor will run at a higher speed, as greater centrifugal force will be required to raise the governor balls to a position that will check the speed of the engine by reducing the opening of the governor throttle valve.

If the desired increase of speed is not obtainable within the range of the adjustments referred to, a smaller governor driving pulley should be employed on the engine shaft or a larger receiving pulley should be placed on the governor, so that the desired engine speed will be required to drive the governor at its normal speed of operation.

Cracks in Boiler Settings—How can settings of horizontal return-tubular boilers be constructed to prevent cracks in the brickwork? F. L. B.

The principal causes of cracks are settling at the foundation, difference in expansion from heat between the boiler and brickwork at points where they come in contact with each other, difference of expansion between connected sections of the masonry, and crushing or dragging action of the boiler at places where it rests on the setting. Serious danger from failure of the setting by crumbling or cracking can usually be averted by providing suitable bolts and binder bars for clamping together the masonry, but cracks caused by changes of temperature grow worse from continued use of the boiler and are rarely if ever absent from boiler settings. The greatest trouble usually arises from those due to unequal expansion between the boiler and setting, and to provide against them requires such a construction of the setting that the brickwork will nowhere be brought closer to the boiler than about 1 inch. The space can be filled with asbestos or mineral wool packed only tight enough to stop off free circulation of air or furnace gases. Cracks due to inequality of expansion of adjacent parts of the brickwork, as where cross walls join the side walls, can be prevented by suitable slip joints. In settings where the boiler is supported on wall brackets, cracks in the side walls are sometimes produced by friction of the wall bearings offering resistance to the difference of expansion between the boiler and the side walls. Cracks from this cause can be obviated by using substantial iron templets under the bearings for distribution of the weight from the boiler brackets over greater lengths of the settings or, better, by suspending the boiler from steel I-beams supported on iron columns that are independent of the brickwork.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Report of Station Operating Committee--IV*

SYNOPSIS—This is the last part of the Report on Oil as Fuel. The first three parts Boiler Operation, Water Treatment and Extraction or Bleeder Turbines appeared in the issues of June 13, June 20 and June 27 respectively.

Oil as Fuel

Communications were addressed to engineers who have had extended experience in the use of fuel oil for power plants, and inasmuch as the use of oil for fuel is at present confined almost entirely to the Pacific Coast, these are practically all Western men.

A letter to the Fuel Oil Department of the Standard Oil Co. of New York brought the following reply, and coming from the largest oil-supply company in the country, it appears to settle the question so far as fuel oil for power-house use in the regions of cheap coal is concerned. While the condition existing at present is abnormal, the price of oil has been steadily increasing for five years or more, and unless new fields are discovered, and on a surprisingly large scale, there does not seem to be any reasonable prospect that oil will compete with coal to any extent.

We quote from the letter of Mr. Fisher:

Answering your letter of the 18th to the Standard Oil Co., Buffalo, the whole question of central-station service no doubt is one of economy, and up to the present time it has not been possible to get the price of fuel oil down to a point where it could compete with coal for generating steam, or at least to guarantee price for a long enough period to warrant someone undertaking the installation of oil for steam generation. This is practically due to the uncertainty of the production and price, which is not the case with coal, prices for coal being more constant. For instance, three months ago oil could be delivered here in New York Harbor in cargo lots for 85c. per bbl., but today I doubt whether it could be done for less than $1.10 per bbl. When you figure about four barrels of oil to equal a ton of coal, you can readily see that oil does not stand very much of a chance. I do not believe that the time is opportune to make any great splurge in the direction that you are aiming.

A. H. Babcock, consulting electrical engineer of the Southern Pacific Co., has charge of the steam-power station that supplies electric current for the local electric lines of that company at the Oakland, Calif., terminals. This station was completed about five years ago, and at the time was completely equipped for the future installation of coal bunkers and stokers should future conditions ever justify the substitution of coal for oil. We quote from Mr. Babcock's letter:

This plant is now showing a switchboard economy of approximately 200 kw. to the barrel of oil, and the load fluctuates from the minimum to between 10,000 and 11,000 kw. with a daily load factor of approximately 0.4.

This station is running on a regular load twenty hours a day in typical railway service.

No investigation was made by way of comparing the advantages of coal vs. fuel oil in Fruitvale power plant, for the reason that the plant is owned by a company that owns large oil fields and had had large experience in handling solid fuel before oil was discovered. Nothing save a prohibitory price of fuel oil, as compared with coal, would drive us to a coal basis; but it was not considered prudent, in view of the discussion at the time the plant was built as to the permanency of the oil supply, to ignore the possibility of a change being forced upon us to a coal-burning basis, in which event, if the plant were not designed to accommodate coal- and ash-handling apparatus and if the boiler settings were not designed to take stokers, such a change would be very expensive if it had to be made; consequently the plant was designed as if coal were to be used, which simply means more space is required within the building.

The ordinary boiler setting is used with almost anything in the shape of a burner that will atomize the oil either by using air or steam. Large claims are made by boiler manufacturers as to the economies their burners will effect, but it is a matter of common experience that almost any nozzle that will intimately divide the oil stream by some vapor under pressure will do very nearly as well as any other, all things considered. Location in the furnaces, generally speaking, is either in the back or the front, with opinions divided as to which is the best location. I do not think we have any trouble with carbon in stationary plants, although in locomotives it is necessary to sand the flues frequently; but the conditions in locomotive fireboxes are different in every respect from those in stationary plants.

As regards flue-gas temperature, all our Fruitvale stack is comparatively thin sheet iron without any lining, and I frequently take visitors to the upper decks of the boiler room to note the temperatures in the flue-gas paths near the stack by means of the bare hand.

As to flue-gas constituents, I have no information. In fact, we do not pay much attention to this in our plants. The general criterion in the fireroom is to see whether the stack is showing any smoke.

Shortly after the 1906 disaster in San Francisco, it was discovered that in the use of fuel oil the very high stacks necessary for forcing air through the coal grates were not at all necessary. Many of the tall stacks were twisted off or so badly damaged they had to be cut off at heights varying from one-third to one-half; and as far as we can see, the results are approximately the same, although when the boilers are forced there is liable to be some smoke. This was rather in the nature of an accidental discovery, because at that time all bricklayers were too busy rebuilding chimneys to pay much attention to stacks.

Regarding the question of Mr. Babcock's discussion, relative to the arguments for front- or back-shot burners, it is our belief that this question is concerned with two features—first, the type of boiler. Boilers with vertical baffles will usually present a larger and more desirable combustion space when fired by the back-shot burner, and in such cases, of which the B. & W. and the Stirling boilers are types, the back-shot burner will permit forcing the boiler to a higher rating than can be obtained on a front-shot burner.

C. R. Weymouth, chief engineer, of Chas. C. Moore & Co., engineers, San Francisco, has devoted a good deal of study to the problem of economy in the use of fuel oil for power-station work. A paper read by him before the American Society of Mechanical Engineers in December, 1908, entitled "Unnecessary Losses in Firing Fuel Oil and an Automatic System for Eliminating Them," was one of the early authorities for the application of fuel oil to power-station use, and contains much valuable information concerning the use of oil fuel for such purposes. We quote from this paper:

UNNECESSARY LOSSES IN FIRING FUEL OIL

The predominating oil used on the Pacific Coast, known as Bakersfield oil, averages about 16 deg. Bé., which is equivalent to 336 lb. of oil per 42-gal. barrel. The ultimate analysis of this oil is about as follows: Carbon, 85 per cent.; nitrogen, 0.2; hydrogen, 12; oxygen, 1; sulphur, 0.8; water, 1.

A number of lighter oils in general use, ranging in the neighborhood of 18 to 20 deg. Bé., would average about as follows: Carbon, 84; nitrogen, 0.2; hydrogen, 13; oxygen, 1; sulphur, 0.8; water, 1.

Certain heavier oils ranging from 12 to 14 deg. Bé., average about as follows: Carbon, 86 per cent.; nitrogen, 0.2; hydrogen, 11; oxygen, 1; sulphur, 0.8; water, 1.

As a result of tests by Edmond O'Neill, professor of Chemistry of the University of California, the calorific value of Bakersfield oil may be taken as about 18,600 B.t.u. per lb., allowing for the presence of about 1 per cent. moisture, as indicated. When corrected for moisture, the net heat units per pound of oil are proportionally higher, although there is a slight loss in furnace efficiency due to the presence of moisture, inasmuch as all such water is evaporated into steam and superheated to the temperature of the escaping gases, involving an amount of heat both sensible and latent.

On the basis of the above analyses, the chemical requirements of air for complete combustion per pound of oil are as shown in Table 1.

In the various textbooks the values given range from 16 to 18 lb. of air per pound of oil, but an average of 14 lb. of air per pound of oil is more nearly correct.

TABLE 1. WEIGHT OF AIR REQUIRED FOR COMBUSTION OF OIL OF DIFFERENT GRADES

Grade of Oil:	Light	Medium	Heavy
Per Cent. of C	84.00	85.00	86.00
Per Cent. of H	13.00	12.00	11.00
Per Cent. of S	0.80	0.80	0.80
Per Cent.of N	0.20	0.20	0.20
Per Cent. of O	1.00	1.00	1.00
Per Cent. of H_2O	1.00	1.00	1.00
Air chemically required per pound of oil, calculated, lb.	14.25	14.02	13.79
Corresponding maximum CO_2 by volume, in dry gases of combustion, per cent.	15.16	15.52	15.89

As no direct experiments have been made showing the loss in boiler efficiency due to various percentages of excess air supply, the writer will present some simple calculations showing the amount of this loss.

It is wellknown that the loss due to an excess of air supply is not only on account of the direct loss in heating the added air to the temperature of the flue gases, but there is a secondary loss due to the fact that corresponding to an excess of air, there results a higher flue temperature not only for the actual amount of air necessary for combustion, but for all such excess air. Calculations as to boiler performance are simplified with oil fuel, as practically complete combustion is secured in a well-designed furnace, the carbon and carbon monoxide usually being burned to CO_2. The stack losses include the sensible heat contained in the dry gases of combustion, the sensible and latent heat in the steam from the combustion of hydrogen and oxygen and in the steam introduced through the burner, and the moisture present in air for combustion.

Assuming complete combustion, and employing a boiler radiation loss of 3 per cent., the writer has various percentages of excess air supply, as given in Table 2.

*Presented at the eighth annual convention of the National District Heating Association, New York City, May, 1916.

TABLE 2. BOILER EFFICIENCY FOR EXCESS AIR SUPPLY

Excess air supply, per cent.	10	50	75	100	150	200
Assumed temperature of escaping gases, deg. F.	400	450	475	490	Over 500	Over 500
Corresponding ideal efficiency of boiler, per cent.	84.2	80.27	77.66	75.22	Under 70.94	Under 67.09
Possible saving in fuel due to reduction of air supply to 10 per cent. excess, expressed as percentage of oil actually burned under assumed conditions ..	0	4.67	7.78	10.68	Over 15.76	Over 20.32

The 3 per cent. used for boiler radiation is subject to some variation, being greater in small boilers and less in large units. For medium units 3 per cent. is probably very close.

It is possible to obtain a fair notion of the percentage of excess air from a mere determination of the amount of CO_2—that is, assuming all hydrogen having been burned to H_2O and all carbon to CO_2. Any simple formula involving element CO_2 must be dependent on an assumed percentage of hydrogen in the oil fuel, but inasmuch as the hydrogen contained is fairly uniform for any given grade of oil, there is but little error in such an assumption.

TABLE 3. POUNDS OF AIR PER POUND OF OIL AND RATIO OF AIR SUPPLIED TO THAT CHEMICALLY REQUIRED

Per Cent. CO_2 by Volume as Shown by Analysis Dry Chimney Gases	Light Oil—C, 84 per Cent.; H, 13; S, 0.8; N, 0.2; O, 1; H_2O, 1		Medium Oil—C, 85 per Cent.; H, 12; S, 0.8; N, 0.2; O, 1; H_2O, 1		Heavy Oil—C, 86 per Cent.; H, 11; S, 0.8; N, 0.2; O, 1; H_2O, 1	
	Pounds of Air per Pound Oil	Ratio Air Supply to Chemical Requirements	Pounds of Air per Pound Oil	Ratio Air Supply to Chemical Requirements	Pounds of Air per Pound Oil	Ratio Air Supply to Chemical Requirements
4	51.40	3.607	51.93	3.704	52.45	3.803
5	41.31	2.899	41.71	2.975	42.12	3.054
6	34.58	2.427	34.90	2.490	35.23	2.554
7	29.77	2.089	30.04	2.143	30.31	2.198
8	26.17	1.836	26.39	1.883	26.62	1.930
9	23.37	1.640	23.56	1.680	23.75	1.722
10	21.12	1.482	21.29	1.518	21.45	1.555
11	19.83	1.391	19.42	1.386	19.58	1.419
12	17.76	1.246	17.88	1.276	18.01	1.306
13	16.46	1.155	16.57	1.182	16.69	1.210
14	15.36	1.078	15.45	1.102	15.55	1.127
15	14.39	1.010	14.48	1.033	14.57	1.056

Mr. Weymouth proceeds to outline the development of a regulating mechanism by which the supply of oil to all burners, the supply of atomizing agents to all burners and the supply of air for combustion for any number of boilers may be automatically controlled from a central point. Briefly, the principles of this automatic regulation are as follows:

A slight variation in the steam pressure on the boilers, due to any variation in the demand for steam, is the primary means of control for a steam regulator or governor which varies the oil pressure at the oil pumps and in the oil main. Corresponding to an increased pressure in the oil main, there is an increase in the amount of oil fired and a rise in boiler steam pressure; and corresponding to a decrease of pressure in the oil main, there is a decrease in the rate of oil fired and a lowering of the boiler steam pressure; this regulator thus maintains a uniform steam pressure on boilers at all loads within the governing limits. The variation in pressure in the oil main is the secondary means for controlling the supply of steam for atomizing purposes and also for controlling the supply of air for combustion.

The supply of steam to burners is controlled by regulating the pressure in a separate low-pressure main common to all burners, the pressure in this main bearing a certain predetermined relationship to the pressure in the oil main and being controlled by a ratio regulator. By means of a specially constructed diaphragm regulator, the opening of the boiler dampers is made to increase or decrease with a corresponding variation of pressure in the oil main, the change in damper opening, in turn, governing the supply of air for combustion.

Under date of Oct. 26, 1915, approximately seven years after the original development of the regulating apparatus, Mr. Weymouth writes as follows:

We have installed these regulators in a number of plants, our latest installation being in an 18,000-kw. plant for the Inspiration Consolidated Copper Co., Miami, Ariz., where the regulators have shown an exceptionally high maintained efficiency under operating conditions.

From my own experience in handling plants ranging from 200 to 10,000 b.hp., I am convinced that the possibilities of attaining and maintaining a high economy through the use of automatic regulating apparatus, guided by proper instruments for determining boiler output and the various flue-gas and feed-water conditions, are great.

The use of fuel oil converts the fireman's duties more nearly into those of a mechanical engineer, and the effect of this upon the personnel of the Western fire rooms is quite noticeable.

Frank H. Varney, chief engineer operation and maintenance of the Pecific Gas and Electric Co., of San Francisco, probably the largest user of fuel oil for electric purposes to be found in the United States, submitted the following, which seems to be quite worthy of a place in our report:

The oil we are using comes from the oil fields in the neighborhood of Bakersfield, Calif. It is transported from the oil fields to a point on San Francisco Bay by a pipe line and from this point is delivered to our power plants by barge.

The following is an analysis of a sample of oil taken at random in one of our plants:

Specific gravity.....0.9682, equals 14.60 deg. Baumé
Water (by distillation).....0.95 per cent.
Flashpoint .....239 deg. F.
Ash .....0.023 per cent.
Sulphur ..... 0.75 per cent
Heating value per pound of oil free from water...18,738 B.t.u.

The oil is burned in a furnace similar to an ordinary hand-fired coal grate, except that the grates are covered with firebrick with spaces between them, placed in such a position as to allow the air to enter directly under the flame at the points where it is most effective. In some cases the grates are omitted altogether and the firebricks are supported on pipes. The oil on reaching the boiler room is heated to a temperature of approximately 180 deg. and is delivered to the burners at this temperature and a pressure of 40 to 50 lb. The oil is atomized in practically all power plants by steam. While compressed air may be used for atomizing, it is found that the quantity of steam used is so slight as to make the installation of an air compressor unprofitable. In normal operation it is customary to use about 3 or 4 per cent. of the steam generated for atomizing, but by proper care in heating the oil and in the design of the burners and furnace, it is possible to reduce this to less than 1 per cent.

It is customary to use not more than four oil burners to fire one boiler, and frequently three are sufficient for a boiler up to 800 hp. There are two methods in prevalent use in introducing the burners into the furnace. The first, known as the front-shot burner, has the burner entering through the fire-doors and shooting the flame back toward the rear of the furnace. In the second method, known as the back-shot burner, the burner is placed at the bridge-wall, the steam and oil pipes running through the ashpit to this point. The burner is pointed toward the front and the flame shoots toward the front of the furnace. In boilers having horizontal baffling in which the entire length of the setting can be used for the furnace, the front-shot burner is usually adopted. In boilers having vertical baffling, such as the B. & W., the back-shot burner is considered superior because it forces the fire toward the front of the furnace, where, owing to the slant of the tubes, there is greater furnace height than in the rear. This gives a larger combustion chamber for the fuel. In Stirling boilers the back-shot burner is also used, and a large combustion chamber running clear up to the level of the bottom of the steam drum is obtained.

As will be seen from the analysis given, the heating value of oil is very much higher than that of coal. Furthermore, a higher efficiency can be obtained with oil just as it is possible to obtain a higher efficiency with good coal than it is with poor coal. It is well known that with a poor grade of coal containing only 10,000 B.t.u., a boiler efficiency of 60 per cent. is all that can be expected, whereas with the best coal having 15,000 B.t.u., an efficiency of 75 per cent. can be obtained. With oil it is simple to obtain an efficiency of 78 per cent. in regular plant operation. On the basis of these efficiencies I have prepared a comparison of the cost of coal and oil:

COMPARISON OF COST OF COAL AND OIL FOR FUEL

	Coal						Oil
B.t.u. per lb.....	10,000	11,000	12,000	13,000	14,000	15,000	18,500
Boiler efficiency.	60	63	66	69	72	75	78
Evaporation from and at 212 deg. F.	6.18	7.15	8.17	9.25	10.4	11.6	14.88
Lb. per boiler hp.	5.58	4.82	4.22	3.73	3.32	2.97	2.32
Lb. coal equivalent to 1 bbl. oil	808	698	611	540	481	431	....
Bbl. oil equivalent to 1 short ton coal	2.47	2.86	3.27	3.70	4.16	4.64	....
Bbl. oil equivalent to 1 long ton coal	2.77	3.20	3.67	4.15	4.65	5.20	....
Price of 1 short ton equivalent to oil at 70c. per bbl.	1.74	2.00	2.28	2.59	2.91	3.24	....
Price of 1 long ton equivalent to oil at 70c. per bbl.	1.94	2.24	2.56	2.90	3.25	3.64	....

The higher efficiency obtained with oil is due largely to the fact that it can be burned with a small amount of excess air, frequently not over 15 per cent. The fact that little draft is required also helps to increase the efficiency by reducing the quantity of air filtering in through the brick setting. For this reason the most economical results are obtained with zero draft in the furnace and a draft at the damper just sufficient to overcome the friction of the gases in passing through the setting. It is possible to operate with a strong draft in the furnace and to reduce the quantity of air by restricting the openings for its passage into the furnace, but it is more economical to leave the openings fairly large and to reduce the air by cutting down the draft at the damper to the lowest possible point.

One of the greatest advantages of oil over coal, especially for a standby plant, is the rapidity with which the fire can be started. It takes only about 30 sec. to light the fire with a torch, and as a full fire is obtained right away, it is not uncommon to have a boiler ready to cut in on the line 30 min. after the fire is started.

Another advantage which applies especially to standby plants is the fact that with oil fuel there is no such thing as a banked fire, for when the steam is not needed the fires are simply put out. This entirely does away with the loss due to poor combustion of coal in a banked fire, which is often very considerable.

In addition to the saving due to the high efficiency obtained from oil, there is considerable saving in labor in the fire room. The oil is pumped from the storage tanks direct to the oil

burners, so that all the fireman has to do is to regulate the quantity of oil, the amount of steam required to atomize it and the amount of air required to burn it. One man can fire six or eight large boilers totaling 5,000 hp., and no labor is required for handling ashes. There is also a considerable saving in the first cost of a plant that is to be fired by oil, as no mechanical stokers are required and no coal- or ash-handling machinery is necessary. The smokestacks do not have to be as high or as large in diameter as where coal is used, and no forced-draft apparatus is required.

In a standby plant where it is necessary to keep up steam on the boilers ready to pick up the load at any moment, the method usually employed is to fire up a boiler until the full steam pressure is reached and then to put out the fire and allow the pressure to drop 20 or 30 lb. and then to relight the fire and bring the steam up to the full pressure again. With this method it is possible to keep up steam by using only 1½ per cent. of the quantity of oil required to operate the boiler at its full rated capacity. This can be done, however, only when the boiler is fitted with a damper that can be shut tight, for if there is a considerable air leakage past the damper it may require 3 or 4 per cent. of oil instead of only 1½ per cent.

Mr. Varney's comments concerning the ease and rapidity with which a boiler can be fired up and put in service with oil fuel should be of particular interest to the Eastern power-plant engineer.

It would seem that standby plants, though regularly burning coal, might be justified in installing fuel-oil burners together with a storage tank and the necessary pumps, regulators, etc., to be used in case of emergency, although the value of such insurance would naturally dictate its advisability in each specific case.

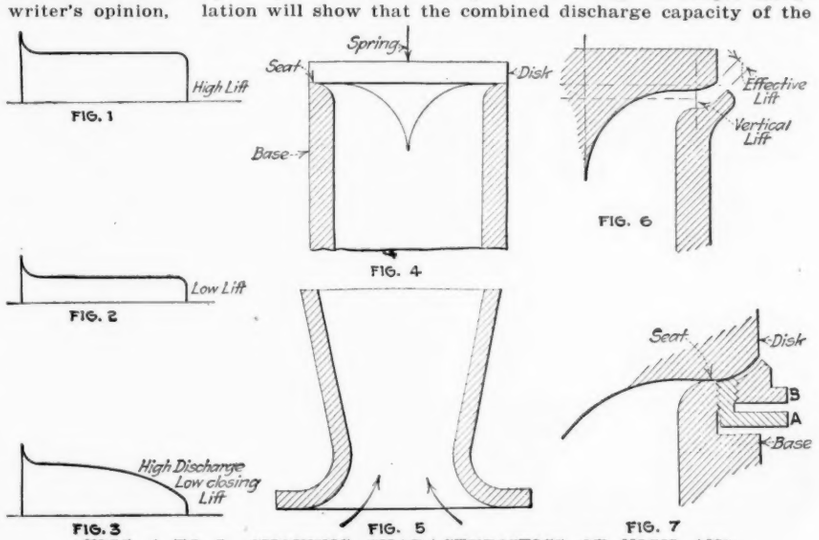
Design of Steam Safety Valves

By George H. Clark†

SYNOPSIS—The author discusses existing types of safety valves and shows that it is possible to produce a valve of high lift as regards discharge capacity and low lift as regards shock at closure.

Safety valves have been in the past and are somewhat at present the result of cut-and-try methods rather than a mechanism based on logical and fundamental principles. Comments intended to bring forth real points of fundamental interest to designers have in general degenerated into a discussion of the results obtained from different types, with little regard to the means by which results are obtained. The object of prime importance in this paper is to present for approval a theory which is intended to be general in its application and is, in the writer's opinion, original in character. In the course of the experimental work undertaken, at least fifty valves were built and tested, none of which, so far as the author knows, represents a design now on the market; instead each valve tested was built to prove or disprove a step in the theory which follows:

It is hard for the engineering public to understand why it is not possible to increase the lift of valves in accordance with present demands for high-capacity valves, without endangering the boilers or the valves themselves, and it is probably true that this misunderstanding is due to the lack of reasonable explanations in which those best fitted to know concur. The concensus of opinion, it would seem, is that high-lift valves, so called, produce more or less shock at closure, which may injure the boiler itself and is usually a serious factor in determining the life of the valve. The A. S. M. E. Boiler Code Committee in its recent report proposed a limitation in the lift of safety valves of approved design.



FIGS. 1 TO 7. SHOWING CHARACTERISTICS OF HIGH AND LOW LIFT VALVES AND TYPES OF ORIFICES

Most specifications in force at present are based either on grate area or heating surface and are recognized to be misleading and entirely inadequate for present-day practice. This is evidenced by the innovations contained in the report of the Boiler Code Committee, which bases the relieving capacity on the greatest possible amount of steam that can be generated and provides that valves shall take care of this maximum amount. The difficulty of this method is the lack of capacity of valves of the present day to provide means of economically taking care of the situation. The author doubts if the demands of the rules laid down by the Boiler Code Committee have come home to the boiler users. Whatever the position of the boiler user, the basis of the specifications are absolutely right and just and they distinctly put the real issue on the valve manufacturer himself.

At this point it is well to cite a few examples of the workings of the proposed rules. One of the most popular units is the 500-hp. water-tube boiler. In general this is equipped with two 4-in. valves on the drums and one 4-in. valve on the pipe leading from the superheater. Such valves are usually of the 45-deg. seat type, and reference to the table of capacities in the proposed rules allows us to determine the required equipment for this boiler. These boilers are often run at 300 per cent. rating, generating approximately 45,000 lb. of steam per hour. If the pressure be taken as 200 lb., it will be found that with the maximum lift allowed in the table, the discharge capacity of one 4-in. valve is 9,420 lb. per hr. This boiler will then require five 4-in. valves. However, the specifications state that should two or more valves be connected to a common base, the nozzle supplying the combination must have an area equal to the combined area of the valves connected thereto. Since most of these boilers have 4-in. valve nozzles, it will be found somewhat difficult to install the required capacity without extensive changes.

The largest single boiler unit is a Stirling type of 2,356 hp. adapted to run at 210 per cent. rating. A simple calculation will show that the combined discharge capacity of the safety valves should be 148,000 lb. per hr. This installation under the rules, would require eleven valves of the maximum size and maximum lift at 200 lb. The safety valves of a boiler of this size would probably be piped outboard, and under the proposed specifications this would require eleven separate discharge pipes. It is customary to set valves connected to the same boiler with a certain range of pressure between their respective popping points. If they are set 2 lb. apart, then the total range of pressure will be 22 lb., or slightly greater than 10 per cent. of the working pressure. The rules require, however, that the installation of valves must relieve the boiler with not greater than 6 per cent. accumulation above the working pressure.

The factors which tend to limit the discharge capacity of the ordinary type of valve when high lifts are attempted are the apparent impossibility of regulation and the shock produced at closure. The actual valuation of the shock produced at closure defies calculation for many reasons, but it can be shown experimentally that the height from which the disk drops to sudden closure plays an important part. The diagrams shown by Figs. 1 and 2 represent graphically the lift characteristics of high- and low-lift valves, a study of

*From a paper read before the Boston Section of the American Society of Mechanical Engineers.

†Instructor, Massachusetts Institute of Technology.

which shows that they are essentially alike in all characteristics, but that in high-lift valves the distance through which the disk drops to sudden closure is much greater than in the low-lift valves. If this is the case, the logical solution would seem to be a valve giving a diagram like that shown by Fig. 3 in which the lift during the blowdown period gradually decreases to a small value before sudden closure takes place. We are not vitally interested in the discharge capacities of valves during the blowdown period if high lift can be maintained at the popping pressure. If their discharge capacity is such that after blowing, the blowdown period is finally reached, the emergency is taken care of, and the installation is safe. To produce a valve that will give the diagram shown in Fig. 3, it is necessary to keep the disk in equilibrium with the boiler pressure, while that pressure is being reduced.

In any safety valve there are three factors affecting the rate of flow over the seat that are characteristics of the seat itself—namely, the vertical lift, the seat angle and the contour of approach to the seat. The flat seat is adapted to open the largest area per unit of vertical lift and hence should be employed, other things being equal. Since the approach to a standard orifice makes the throat sectional area 100 per cent. efficient, the characteristics of such an orifice should be employed. Prof. E. F. Miller, of the Massachusetts Institute of Technology, was the first to round the edges of a safety valve to increase the efficiency of discharge per unit of lift and in so doing took a long step in the direction of high safety-valve efficiency. The valve shown in Fig. 4, in which the standard orifice or, better, its practical equivalent is incorporated, follows the theory proposed by him several years ago. The full benefit of the standard orifice would be available regardless of the type of lip provided if the passage area from the seat outward increased, but to produce a high-lift valve the maximum available pressure between the lips consistent with maximum discharge must be used.

In a standard orifice the area of each section after the throat section is equal to that at the throat section, and it has been found that the pressure at the throat section and at each section of equal area thereafter is close to 0.6 of the boiler pressure and that the back pressure into which this orifice discharges has no effect on either the weight discharged or the existent orifice pressures unless this back pressure exceeds 0.6 of the boiler pressure. If it does exceed 0.6 of the boiler pressure, the discharge capacity is reduced and the pressure throughout the orifice is increased. With an orifice of the shape shown in Fig. 5, but of equal throat sectional area, the weight discharged is the same as before, but the pressure after the throat section varies inversely as the area. It follows that, to produce maximum pressure between the lips, there must exist at full lift an equality of area at each section outward from the throat of the orifice which is located at the seat. Since the effective disk diameters are constantly increasing, the effective lift must be reduced as the passage is lengthened. This can be done by giving the passage an upward slope, as is shown by Fig. 6.

If a valve of these characteristics is constructed and blown, it will be found to have an extremely high lift, and the opening of such a valve is so sudden as to be truly explosive. A very large percentage of the pop lift is sustained if the popping pressure is held constant, and when such a valve starts to blow down, the lift gradually decreases during the blowdown period until a certain point is reached where the pressure becomes such that the valve disk drops suddenly to closure. This construction will produce a blowdown which is likely to be a third of the boiler pressure and forces its designer to incorporate means of regulation which will give a small blowdown without interfering with the capacity or other features of valve action.

A valve that chatters or vibrates at the instant of opening or sizzles at that time shows a lack of lifting force at low lifts, and one that shows an excessive blowdown demonstrates that the lifting force at low lifts is too great to allow of closure, and it follows that the requirements of warning and blowdown are somewhat combative. Blowdown is an absolute necessity on the spring-loaded type, owing to the existence of lifting force outside the spring chamber, and it is clear that attempts to reduce the blowdown will tend to decrease the lift and relieving capacity. In general, the real secret in the design of a perfect safety valve lies, not in the production of excessive lifting force, but in controlling and adjusting it.

Fig. 7 shows a valve which has means for adjustment, based on the production of variable lifting force. The two annular rings A and B carry on their upper surfaces curves that approximate in shape the curve on the disk. The inner ring A, which may be called the warning ring, is threaded upon the base of the valve just outside the flat seat and carries threaded upon it the ring B, which is adapted to control the blowdown. These rings may be lowered away from the disk, or given initial clearance. If both of these rings are lowered an extreme distance, when the valve tends to open, no lifting force will be available; but if the ring A is raised to a position near the valve disk, a lifting force will be provided which will depend, first, on the pressure produced between it and the disk and, second, on the extent of the disk area on which this pressure acts. The pressure depends on the area of the passage, and the area in the valve is a function of the initial clearance, and the shape of the curve. As the blowdown ring B is raised from its lowest position, there is a tendency to build up pressure between it and the disk when the valve is open, which tendency increases as the disk is approached; and if a reasonably large clearance is left, this ring produces almost no lifting force at low lift, since the area of the passage along it is large in comparison to that over the seat. It follows, also, that as the disk lifts, the effect of this initial clearance on the area of the passage becomes less and less as lifting continues.

The author has succeeded in getting some diagrams from valves under service conditions which show in detail the results of the methods of regulation employed. Fig. 8 is a photograph of the arrangements of the valves for testing at the power plant connected with the new buildings to be

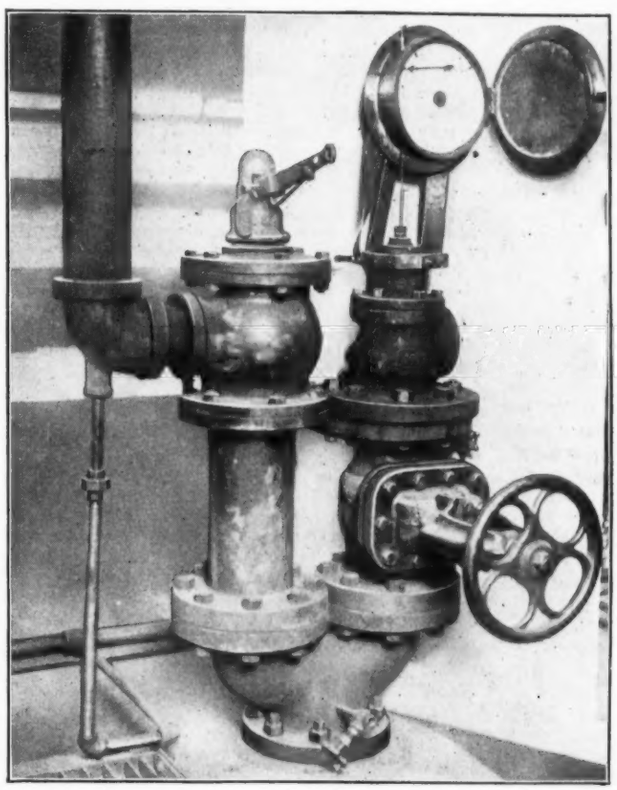


FIG. 8. VALVES ARRANGED FOR TESTING

occupied by the Massachusetts Institute of Technology. The recording apparatus consisted of a clock motion adapted to turn a chart once in 15 minutes. Bearing on this chart was a pen rigidly connected to the spindle of the valve and adapted to leave a record thereon of lift with respect to time, the lifts being multiplied by a ratio of approximately 4 to 1.

Fig. 9 is a chart of the performance of a valve with a 2½-in. seat. This valve was blown at 150 lb. gage and showed under the existent regulation, 5 lb. blowdown and almost no warning. That it may be clearly understood, it has been transferred to a diagram, Fig. 10, having rectilinear axes, on which is plotted the scale of lifts which resulted from calibrating the recording lift gage with an accurate micrometer. The sudden pop lift is shown at A and the corresponding sustained lift at B. The variations in lift at B are further evidence of the readjustments of pressure which determine the pop and sustained lifts. The discharge capacity of this valve was such that the popping pressure was not maintained, and the curve from B to C shows the reduction in lift, which in this type always corresponds to a reduction in boiler pressure. At C the valve closed suddenly with less than half its initial sustained lift prevailing.

Fig. 11 shows the same valve with its outside, or blowdown ring lowered slightly. This, like the one preceding, is a photograph of the actual diagram and has not been transferred to rectilinear axes because of the difficulty in showing the fluctuations in lift.

It was decided after the two preceding diagrams were secured to change to a smaller valve of lower discharge capacity under which the pressure could be regulated as desired. The new rules, if put into force, will allow 6 per cent. accumulation of pressure, and the three next diagrams show what advantage may be taken of this accumulation.

Fig. 12 is a chart taken from a 2-in. valve in which the pressure was not allowed to accumulate. The low closing lift in comparison to the sustained lift is to be noted. Fig. 13 shows the same valve with an accumulation of pressure over the opening pressure of 4 per cent.

In Fig. 14 the valve was regulated to give a low sustained lift and was then given the full 6 per cent. accumulation. The discharge capacity at 6 per cent. accumulation is more than 100 per cent. greater than that at the opening pressure. The low closing lift is to be noted as before. The blowdown on this valve was about 2 lb., so that this chart was made between a maximum pressure of 159 lb. and a minimum pressure of 148 lb. The new specifications rate valves on their sustained lift at the popping pressure, and so it is clear that with this type the basis is amply safe.

The diagram (Fig. 15) shows the characteristics of a safety valve that is absolutely new both in conception and results. It has been the aim of safety-valve designers to produce a valve which relieves a boiler with an action that is smooth and containing as few sudden fluctuations in pressure as is possible. The Boiler Code Committee recognized the capabilities of standard valves to respond to accumulated pressure by incorporating the 6 per cent. accumulation rule. The ideal safety valve for practical purposes is one in which a reasonably low lift is maintained at the popping pressure, the boiler, exactly as before, but if it has not the required capacity, the pressure will accumulate and the increase of lift resulting with only the inner ring in action will finally bring the outer ring into action and a second pop will occur. This pop will result in a high lift with corresponding high discharge capacity, and the valve size may be proportioned to give the required safety.

There is reason to believe that we shall soon have boilers that will operate at 600 lb. A 4-in. valve set at 600 lb. will have a spring load of approximately 7,540 lb., or about 3½ tons. If a 2-in. valve can be constructed to give twice the lift of the 4-in., it will have the same discharge capacity, but its spring load will be only one-quarter as great. In other words, the discharge capacity varies as the first power of the diameter and the lift, but the spring load, which is independent of the lift, increases as the square of the diameter. It seems clear from this that high-pressure boilers will of necessity require small-diameter high-lift valves.

The effect of back pressure in the casing of a safety valve has been much discussed. It has been said that it may operate in two ways to reduce the discharge capacity—first, the effective lifts may be reduced, and second, it has been held that back pressure reduces the efficiency of discharge of the orifice. If any of the disk area is exposed to back pressure, the lifts will be reduced to some extent, but consideration of the theory of flow through an orifice, and particularly a standard orifice, brings out the fact that as long as the back pressure in the casing is less than 0.6 of the boiler pressure, the discharge of the orifice is not affected.

There are many economical advantages to be gained by a valve that will operate without harmful effect of back pressure. First, the sizes of discharge pipes may be reduced, and second, several valves may be connected into a common discharge pipe. Fig. 16 shows a valve that has the foregoing advantages. In the first place valves of high lift—and by that is meant higher lift than any of those obtainable at

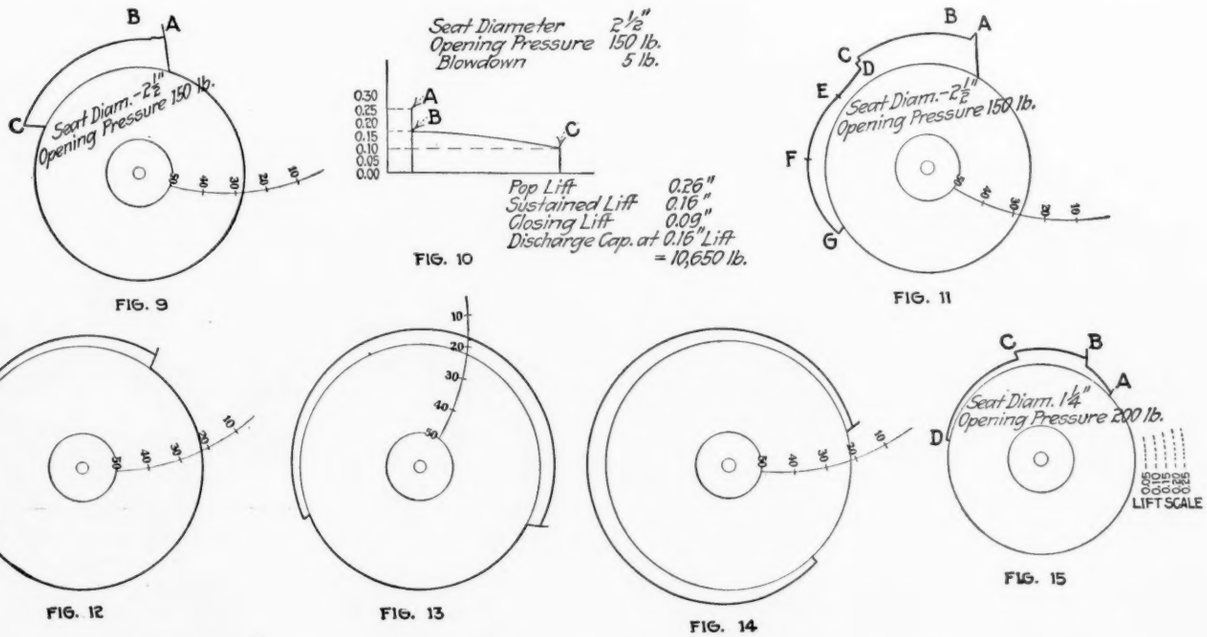


FIG. 9 FIG. 10 FIG. 11

FIG. 12 FIG. 13 FIG. 14 FIG. 15

FIGS. 9 TO 15. SHOWING PERFORMANCES OF DIFFERENT VALVES BY MEANS OF CHARTS

but one which will on the slightest accumulation respond with an extremely high lift to take care of the emergency. If a low lift is available at the popping pressure for ordinary relief, a low blowdown may be incorporated, the condition imposed by absolute safety being that at slightly above the popping pressure the lift will have increased to such an extent that any possible emergency will be taken care of.

Fig. 15 shows a diagram from a valve that produces the above action and is what may be called a second-opening valve. Many of this type have been built, and it has been found that with the proper regulation of rings, all valves having two rings will produce this action in modified form. Imagine first, one of the ordinary type blown with the outside ring removed. This would result in a low lift and a very low blowdown. Now suppose that the blowdown ring is in place, but that it is given such a large initial clearance that the valve will act, if it has sufficient capacity to relieve present—must be guided from above, as guides in the base will cause too great a drop in pressure on the disk area. In this view the disk is made in the shape of a hollow piston, which is guided by a cylindrical sleeve inclosing the spring chamber. The fit between these is extremely loose, and no attempt is made to prevent leakage by the disk. This loose fit insures that the disk will not bind because of expansion or contraction between the members due to temperature changes and is long enough in relation to the diameter of the disk so that it will never cock. Its looseness alone insures that the disk will come to a uniform bearing on the seat, and it has been found that under no conditions of back pressure has the leakage by it been sufficient to produce pressure in the spring chamber, which is always fitted with a vent. With this type the back pressure may be built up to nearly 0.6 of the boiler pressure without hampering the discharge capacity, and since the back pressure is a result of the effective opening of the

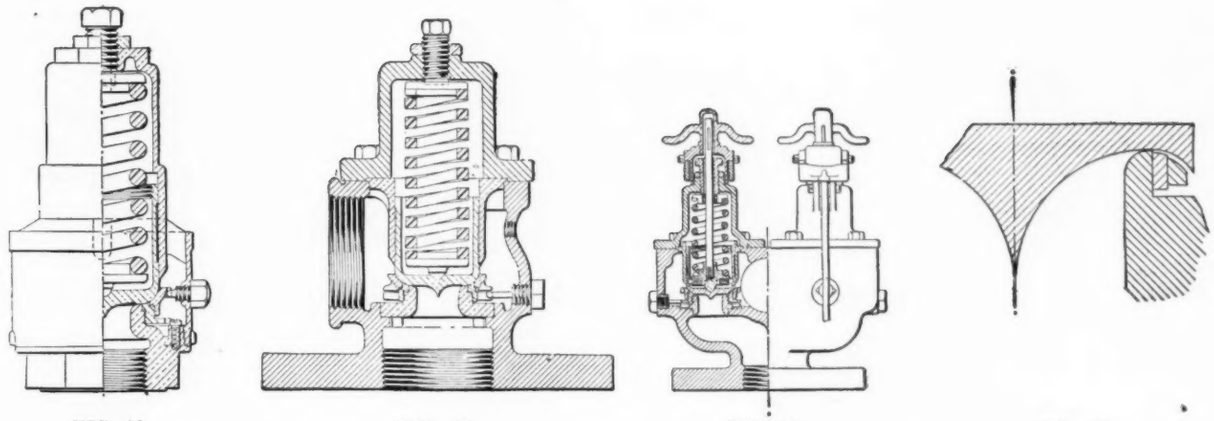


FIG. 16 FIG. 17 FIG. 18 FIG. 19

FIGS. 16 TO 19. SHOWING VALVES DESIGNED TO AVOID EFFECT OF BACK PRESSURE

valve, it has no effect whatever on regulation if it is brought about by the means shown.

In the case of duplex or triplex valves having a common discharge pipe, the opening of one will tend to open the other, owing to the exposed area outside the seat and the impossibility of back pressure acting downward on the disk.

Fig. 17 shows stationary type and Fig. 18 the proposed marine type of exceedingly large capacity. It must be understood that the commercial types of valves shown in these illustrations do not depend on back pressure for any part of their action, but are in every case adapted to work with it, without harmful effect. Having shown a valve in which there is substantial increase in discharge capacity over those in use at present and having demonstrated that this may be accomplished with lower closing lifts than are now the rule, attention is called to a possible improvement in this type. The reader will have noticed that in all the types shown the passage turns upward from the seat region, and it is also clear that, so far as the area conditions go, it might as well be turned downward. If it is turned downward, the area conditions will remain constant, as illustrated by Fig. 19, but there will be available as lifting force, a factor which would act upward in the disk and which is commonly known as a jet action. A few valves of this type have been constructed, and the results gained have been convincing of their possibilities. Enormous lifts have been attained with the same absence of shock at closure as with valves herein described. The problem has been by no means solved, but advances have been made in a direction that tends to indicate that it will be solved finally and will result in enormous discharge capacities per inch of valve diameter with the same efficiency per unit of lift.

Penn State Convention, N. A. S. E.

The seventeenth annual convention of the Pennsylvania State Association of the N. A. S. E. was held at Williamsport, June 15, 16 and 17, with headquarters at the Park Hotel. The meetings of the delegates were held in the large banquet hall, one end of which was arranged and decorated for the use of the supplymen in the display of their goods.

On Friday morning at 10 o'clock the official opening of the convention took place, with Albert Munzinger, chairman of the local committee, occupying the chair. Mr. Munzinger after greeting the delegates and guests, introduced Mayor Junius Fischer, who gave an address of welcome which was responded to for the engineers by James D. Rostron, past state president. Vice-Mayor Harry Myers spoke of the necessity of efficient engineers and was ably answered by Samuel B. Forse, national treasurer of the organization. Walter H. Damon, national president, of Springfield, Mass., who was delayed in travel, made the closing address and spoke of the general waking up in the national and state work of the

DELEGATES AT THE SEVENTEENTH ANNUAL CONVENTION OF THE PENNSYLVANIA STATE ASSOCIATION OF THE N. A. S. E., JUNE 15-17, 1916, AT WILLIAMSPORT, PENN.

N. A. S. E. The gavel was then handed to the state president, Peter O. Johnson, who appointed the necessary committees. The meeting then adjourned until 1:30 p.m.

On Friday evening a smoker was held, at which Herbert Self, of the Peerless Rubber Co., Wiliam Murray, of Jenkins Bros., and Jack Armour, of "Power," entertained. Refreshments were served. On Saturday morning a visit was made to the E. Keller Co., by whom the group photograph was taken. At the closing session all the delegates voted their mileage back to the association to be used by the license committee in their efforts to obtain a state license law.

The newly elected state officers are: Lewis Evans, president; Ernest Hoff, vice-president; Roy B. Ambrose, secretary; Ralph Davis, treasurer; Charles Kehrer, conductor; M. P. Connelly, doorkeeper. Peter O. Johnson was recommended as state deputy. The officers were installed by Walter H. Damon, national president.

Retiring President Peter O. Johnson was the recipient of a past president's jewel National Treasurer Samuel B. Forse making the presentation speech.

Sharon, Penn., was selected as the next place of meeting in June, 1917.

American Boiler Manufacturers

The twenty-eighth annual convention of the American Boiler Manufacturers' Association was called to order by President W. C. Connelly at the Hollenden, in Cleveland, on Monday, June, 19.

Thomas E. Durban, chairman of the American Uniform Boiler Law Society, created at the Erie meeting of the Boiler Manufacturers a year ago, presented his report.[1] He concluded by announcing that the committee had found strenuous opposition to any effort in the direction of examining and licensing boiler attendants and should confine its endeavors in the future to securing the adoption of the A. S. M. E. Boiler Code by the various states. A committee was appointed to consider upon what states the activities of the society should next be concentrated. George A. Luck, deputy chief of the Boiler Inspection Department of Massachusetts and chairman of the Board of Boiler Rules of that state, defended the position of that board in refusing to accept the A. S. M. E. Code upon the ground that they had already in force requirements more stringent than those of the Code and considered that the adoption of the latter would be a step backward. He instanced the requirement of Massachusetts of a factor of safety of 5 for lap-seam boilers, while the Code requires a factor of only 4. He discussed the following amendments to the existing Massachusetts rules, which amendments were approved by the governor on May 12, were effective immediately upon such approval with relation to boilers already installed and will become effective six months after such approval in so far as they relate to new boilers. Their provisions may be made immediately effective in any particular instance by the board upon application.

P. 5, par. 1, Sec. 1, Part 2: "The pressure allowed on a boiler constructed entirely of cast iron with the exception of the connecting bolts and nipples and installed within this commonwealth on or before July 2, 1915, shall not exceed 25 lb. per sq.in. The pressure allowed on such boilers installed after July 2, 1915, shall not exceed 15 lb. per sq.in."

This brings the Massachusetts rules in accordance with the A. S. M. E. Code so far as the later installations are concerned.

P. 7, par. 7, Sec. 2, Part 2: "Safety valves on boilers **installed after July 2, 1915;** must be connected to a separate nozzle or opening in the boiler independent of any other steam connection and as close as possible to the boiler."

The words in heavy face are added.

P. 8, par. 10, Sec. 2, Part 2: "Substitute the following for diagram on page 56."

This relates to fusible plugs, and both diagrams were shown on page 752 of "Power" for May 23, 1916.

P. 10, par. 13, Sec. 2, Part 2: "When the steam gage of a boiler is connected to a water column pipe there shall be brass pipe and fittings from the steam gage to the water-column connections."

The law requires the connections to gages to, "be made of brass pipe and fittings from the boiler to the gage." Some inspectors therefore insisted that when the gage was connected to the water column or the water-column connections, the large pipe connecting the column to the boiler must be also of brass. This was not the intent of the law, and the amendment is designed to make it clear that the brass-pipe column connection between the gage and the water is sufficient, although to one not familiar with its purpose, it leaves the original contention still open.

Amendments 14 and 15 are repealed and the rules restored, which read as follows:

A boiler having 1 sq.ft. of grate surface shall be rated at 3 hp. when the safety valve is set to blow at over 25 lb. pressure per square inch.

A boiler having 2 sq.ft. of grate surface shall be rated at 3 hp. when the safety valve is set to blow at 25 lb. pressure per square inch or less.

In the amendment now rescinded the 25 lb. pressure was changed to 15 lb.

P. 26, par. 8, Sec. 2, Part 3: "Pressure parts of superheaters attached to boilers or separately fired shall be of wrought iron or cast steel. Cast iron for pressure parts of superheaters is prohibited."

P. 26, Sec. 2, Part 3: "Heads of steam domes shall be convex, curved outward from the shell."

The law originally said that the head should be convex without saying whether the convexity should be toward the inside or the outside of the boiler.

In the sixth paragraph of the same amendment: "When the opening in the shell to a steam dome is 4 in. in diameter or larger, the opening shall be reinforced to compensate for the metal removed along the longitudinal diameter of the opening." The amended rule said simply that "when a hole larger than 4 in. in diameter is required in a boiler which is constructed with a dome, it shall be reinforced to compensate for the metal removed," without regard to where the hole might be located.

Par. 27, Sec. 3, Part 3: "Any inspector holding a commission or certificate of competency as an inspector of steam boilers for this commonwealth may make final inspection and test on a boiler built under rules of the Board of Boiler Rules of the Commonwealth of Massachusetts provided the authorized manufacturer of said boiler or his representative makes affidavit under oath that said boiler has been so constructed and furnishes the record of a properly authorized inspector who has followed the construction of the boiler." The only change is the addition of the word "authorized".

P. 33, par. 4, Sec. 10, Part 3: Repeal "The thickness of plates in a shell or drum shall be of the same gage."

P. 34, par. 16, Sec. 4, Part 3 amended by explaining that "convex" means curved outward and "concave" inward.

[1]This report was substantially as appears on p. 38 of this issue.

MEMBERS OF THE AMERICAN BOILER MAKERS ASSOCIATION AT THE D. CONNELLY BOILER CO.'S PLANT, CLEVELAND, OHIO

P. 43, Sec. 4, Part 3: "All stay-bolts except those in vertical boilers having furnaces not exceeding 44 in. diameter shall be drilled from the outside end to a depth of not less than ½ in. inside the boiler plate, and drilled to a diameter not smaller than $\frac{3}{16}$ in."

Hollow stay-bolts with a hole not less than $\frac{3}{16}$ in. diameter and undrilled flexible stay-bolts of a design approved by this board may be used. If a hole larger than $\frac{3}{16}$ in. is used, this hole shall be deducted from the cross-sectional area of the stay-bolt at the base of the thread in computing the allowable load on the stay-bolts."

P. 44, Sec. 4, Part 3. "The calking edges of plates and butt straps shall be planed wherever possible not less than ⅛ in. to remove the distorted edges of the plates."

The amendment consists of insertion of the words "wherever possible," planing being not universally practicable.

P. 44, par. 53, Sec. 4, Part 3: "A feed-pipe connection may be fitted with a brass or steel boiler bushing."

The word "may" substituted for "shall."

P. 45, Sec. 4, Part 3: "Steel castings shall conform to the Class B specifications of the American Society for Testing Materials." This makes this provision the same as in the A. S. M. E. Code.

Amendments 49, 50, 57 and 66 on pages 48, 50 and 52 of the Rules, relating to feed pipes, gage-glass connections and longitudinal lap cracks are transferred from Part 3 to Part 2, making them apply to boilers now or hereafter installed. Mr. Luck announced that Detroit had adopted the Massachusetts rules for air tanks, and that Massachusetts had gotten out a set of rules for ammonia safety valves[2].

H. A. Baumhart, member of the Ohio Board of Boiler Rules, said that Ohio has not yet adopted the A. S. M. E. Code, but expects to eventually, and in the meantime accepts boilers made under it. On account of the present difficulty in procuring new boilers, there have been innumerable requests to install second-hand ones and the factor of safety has been temporarily lowered on such boilers from 8 to 6. They have also allowed boilers removed from the state to reënter without the penalty of loss of pressure prescribed by the original rules. Mr. Durban pointed out that most of the points of difference between the Massachusetts law and the A. S. M. E. Code affected only old installations and that what the boiler makers wanted was uniform laws affecting new work.

In the afternoon session resolutions on the death of James D. Farasey, who served the association as its secretary for 19 years, were adopted; President W. C. Connelly presented his address; Dr. J. S. Unger, of the research bureau of the Carnegie Steel Co., presented a paper illustrated by lantern slides, describing experiments made with rivets the sulphur content of which was varied from 0.030 to 0.180 without making any apparent difference in the physical properties. Samples of rivets bent, crushed, flattened, stretched, etc., were exhibited, and one had to consult the labels to tell which were the higher in sulphur. The effect of the sulphur content is, however, likely to be affected by the presence of other impurities, and the samples had but 0.012 per cent. phosphorus Capt. James Rees, of Pittsburgh, showed samples of rivets (one 2 in. diameter) driven cold. They were driven with pneumatic hammers in the field on gasometer work by the Riter-Conley Manufacturing Co., of Pittsburgh.

The National Tube Co. showed a number of films illustrating the manufacture of steel pipe from the digging of the ore to the final crushing and pressure tests.

A topical discussion upon factory charges followed, in which many of those present participated.

A new constitution and bylaws were adopted, which among other changes dropped the words "of United States and Canada" from the title, it being held that American Boiler Manufacturers' Association was broad enough to include any who desired to enter. D. J. Champion delivered an address on "Fair Recompense."

Tuesday morning was devoted to routine business and an executive session. Vice-President C. V. Kellogg delivered an impressive address on the commercial side of the boiler makers' business.

Tuesday afternoon the Otis Steel Works and the shop of the D. Connelly Boiler Co. were visited, and a banquet at the Hollenden was the concluding event.

The principal speaker at the banquet was I. J. Lietsch, who spoke to the subject, "Costs," but dealt largely with the relations of employer and employee. Brief speeches were made by the retiring president, W. C. Connelly; the incoming president, M. H. Broderick; David J. Champion, who replied for the ladies; H. N. Covell, the newly elected secretary-treasurer; Michael Fogarty, boiler manufacturer, of New York; D. M. Metcalf, chief inspector of steam boilers, Province of Ontario, and S. F. Jeter, Chief Engineer of the Hartford Steam Boiler Inspection and Insurance Co.

[2]Published in "Power" for Nov. 30, 1915, p. 753.

The following officers were elected for the ensuing year: M. H. Broderick, Muncie, Ind., president; C. V. Kellogg, Chicago, Ill., vice-president; H. N. Covell, New York, secretary-treasurer.

Executive Committee—G. S. Barnum, New Haven, Conn.; E. C. Fisher, Saginaw, Mich.; Isaac Harter, Jr., New York; Louis Mohr, Chicago.

Connecticut State Convention N. A. S. E.

The annual convention of the Connecticut State Association of the N. A. S. E. was held at New Haven, June 23 and 24. The sessions of the delegates were held in the lodgeroom on the upper floor of the Music Hall, while the large auditorium on the main floor was arranged and filled up for the mechanical display of the Supplymen.

At 10 o'clock on Friday morning the opening exercises of the convention took place, State-President James McGee presiding. W. B. Kipner, president of the Board of Aldermen, welcomed the delegates and guests to the city, and hoped that their visit would be pleasurable and profitable. He was fittingly responded to by National-President Walter H. Damon and W. J. Reynolds, past national president. The delegates then went into executive session, and after the chairman had appointed the necessary committees, the meeting adjourned until 2 p.m.

At 8 p.m., on Friday evening an entertainment was given in the exhibition hall. B. J. Reynolds, chairman of the local committee, made a short address and introduced Walter H. Damon, national president, as toastmaster. Lieutenant-Governor Clifford B. Wilson spoke of the exceptional qualities of Connecticut, and W. J. Reynolds told of the growing necessity for efficient engineers. Herbert Self of the Peerless Rubber Co., Billy Murray of Jenkins Bros. and Jack Armour of "Power" entertained.

At the meeting of the Supplymen's Association all of the officers were reëlected as follows: Thomas H. Platt, president; John Lotz, Jr., vice-president; Harry Glynn, secretary-treasurer; Frank S. Bulkley, Sandy Smith, Fred S. Upson, trustees.

At the closing session of the delegates on Saturday afternoon it was voted that a committee be appointed to cooperate with a committee of the Supplymen to invite the New England States Commercial Engineers to amalgamate with them in holding a combined convention at Bridgeport, Conn., in 1917. The state officers were elected as follows: E. E. Thomas, president; William H. Brown, vice-president; O. A. Thomas, secretary-treasurer; Andrew Anderson, conductor; R. W. Heuser, doorkeeper; James McGee, trustee; Frank N. Hastings, State deputy. The officers were installed by Past State-President Charles D. Osborne. William J. Reynolds presented jewels to James McGee, Frank N. Hastings and Charles M. Dowd.

The festivities of the convention closed with a shore dinner at Savin Rock on Saturday evening, the feature of which was the presentation of a handsome silver loving cup to National-President Damon.

Ohio Engineers Meeting

The Ohio Society of Mechanical, Electrical and Steam Engineers met at Cleveland on June 22 and 23. The opening session was called to order by President James L. Skeldon, of Toledo, Ohio, at the Statler Hotel at 10 o'clock on Tuesday, and a paper was presented by E. G. Bailey, on the measurement of water by weir meters. Mr. Rowley, of the Johns-Manville Co., gave an address on "Insulation for Heat, Cold and Sound," and the president an extemporaneous discussion of "Specifications from the Bidder's Standpoint." In the afternoon a visit was made to the shops of the Brown Hoisting Machinery Co., followed by an excursion by boat to Euclid Beach.

On Friday morning a meeting of the council was followed by the presentation of papers by F. W. Ballard, on the "Making of Electrical Rates"; the "Use of Powdered Coal," by Joseph Harrington; and "Illuminating Practice with the Latest Mazda Lamps," by H. H. Magdsick, of the National Electric Lamp Association. The society indorsed the Boiler Code of the American Society of Mechanical Engineers and appointed a committee to consider the advisability of combining with the Ohio Socieyt of Engineers. In the afternoon a visit was taken to the testing laboratories, administration buildings, etc., of the National Electric Light Association at East Cleveland.

Report to Boiler-Law Society

Thomas E. Durban, chairman of the American Uniform Boiler-Law Society, in Bulletin 4 reports that in New York the Boiler Code of the American Society of Mechanical Engineers, which the Boiler-Law Society hopes to have adopted in every state, will likely be taken over by the Industrial Commission. Mention is made of the fact that it is better that the Industrial Commission take over the Code than that it be adopted by the Legislature, for if the commission takes it over, changes as made from time to time may be put in force without special act of the Legislature.

The Legislature of Louisiana closes July 6, and at the time of going to press it is uncertain whether or not the Code will be adopted, but hopes are held that it will be. It is planned to get the Alabama Legislature to adopt the Code through the efforts of the local section of the American Society of Mechanical Engineers in Birmingham. In Illinois the matter of getting the Code adopted by the Legislature has been placed in the hands of Louis Mohr.

The governor of Texas favors the Code and it is felt that, through the coöperation of others interested, it may become law in the Lone Star State.

P. J. McBride, commissioner of labor for the State of Kansas, will have the bill introduced in that state for the purpose of adopting the Code. In St. Louis the matter of adoption is in the hands of the Councils. John C. McCabe, chief boiler inspector for the City of Detroit, is working with Prof. John R. Allen, of Ann Arbor, to get the Code adopted by the Michigan Legislature.

Mr. Durban advises that due to lack of time and funds it will be necessary to concentrate effort on a few of the larger states having the most boilers, so that in the event of the adoption of the Code by these states, the momentum gained might carry activity on for a greater length of time and with better results than would be possible under the methods pursued during the last two years. He further advises that it will be impossible for him to devote as much time to this work in the future as he has in the past.

Changes in Ohio Boiler Rules

In a supplement to the 1916 rules of the Board of Boiler Rules of Ohio the following changes were announced: "The Chief Deputy Inspector is expected to authorize all inspectors, both general and special, to collect the $1 annual inspection certificate fee at the time of the annual internal inspection. This action was taken after a decision by the Attorney-General that special inspectors, as some insurance-company inspectors, are duly commissioned by the state. Therefore insurance companies employing such inspectors will be required, after July 1, 1916, to collect this fee at the time of the annual inspection and forward the same to the Division of Boiler Inspection of the Industrial Commission.

By resolution, paragraph 3, p. 33, Part 2, Sec. 1, and paragraph 32, p. 71, Part 3, Sec. 3, of the 1916 rules, were made to read:

A patch on a shell or drum may be used and the pressure maintained provided the size and design is such that in the opinion of the Boiler Inspection Department, the original construction is not weakened. If the patch does weaken the boiler, the pressure must be governed by the value of the patch.

A new long form data report covering the boiler, together with a sketch of the patch on the back of the report, must be forwarded to the Boiler Inspection Department.

Nearly all the inspection report blanks heretofore used by the department have been changed. Copies of these forms have been sent to insurance companies and others directly concerned. Truck locomotives are defined in this supplement.

The supplement defines portable boilers as, "all boilers not in the locomotive, fire-engine and automobile class or which are not attached to a permanent system of machinery or fixed location, in which case they will be considered as part of the installation. Boilers which are moved from place to place, whether on wheels, skids or other movable bases will be considered portable boilers and shall be inspected according to the book of rules, unless used for the purpose which exempts them according to Sec. 2, p. 5, revised Book of Rules, issue of 1916."

Beginning July 1, 1916, the department will adopt a fixed date for each boiler-inspection certificate issued, so that the certificate will read, "good for twelve months from the same date each year thereafter, provided the boiler inspection is made within thirty days prior to or thirty days after the particular date." This will give the insurance company 60 days to make this inspection, which is considered ample.

Cast-iron sectional boilers installed since July 1, 1913, must be equipped in accordance with Sec. 4, Part 1, p. 28, of the 1916 rules, and should include stop valve in the main steam outlet of the outside screw and yoke type, and a safety valve of the proper size in accordance with the grate area, see p. 108, paragraph 3, when same may be exempted from further inspection.

Cast-iron sectional boilers that were installed prior to July 1, 1913, must be equipped with the proper size safety valve and if not otherwise equipped are subject to inspection, and the owners or users must have certificate from the Boiler Inspection Department permitting their operation. If properly equipped, they may be also exempted.

Inspectors are cautioned about being careful in taking measurements, particularly of the thickness of plate, the pitch of rivets and of stay-bolts.

Steam Fitters Meeting

The twenty-eighth annual convention of the National Association of Steam and Hot Water Fitters was held at St. Charles Hotel, Atlantic City, June 21 to 23, attended by about 150 members and twice as many guests of the association. The attendance of members at this convention was the largest in the history of the association. Much of the time was taken up in executive sessions in discussion of trade questions. Papers read in open sessions will be referred to in subsequent issues.

The following officers were elected for the ensuing year. President, Juan A. Almirall, New York; first vice-president, William H. Oakes, Massachusetts; second vice-president, Frank G. Carthey, Utah; third vice-president, Edmund Grassler, Wisconsin; treasurer, J. E. Rutzler, New York. Henry B. Gombers, 260 West Broadway, New York City, was elected secretary of the Association for the twentieth term. Board of Directors: N. Loring Danforth, New York, chairman; John T. Bardley, Missouri; Noble P. Nishop, Connecticut; Julius A. Ziesse, Michigan; Juan A. Almirall, New York; William H. Oakes, Massachusetts; Frank G. Carthey, Utah; Edmund Grassler, Wisconsin; J. E. Rutzler, New York. Sergeant-at-Arms, John C. F. Trachsel, Pennsylvania.

The committee on standards, of which William T. English, of the Walworth-English-Flett Co., of Boston, is chairman were instructed to report at the next annual meeting with recommendations for adoption of the association of standards for screwed fittings and screwed valves.

Boiler Plate Rule Amended

The executive committee of the Board of Supervising Inspectors of the United States Steamboat-Inspection Service has adopted a rule eliminating the requirements for reduction of area of steel boiler plate, pending an investigation by the Bureau of Standards. The amendment was approved by the Secretary of Commerce on June 7, 1916.

The requirements referred to and which were eliminated were contained in the first paragraph of Section 5, Rule I, General Rules and Regulations of the Board of Supervising Inspectors. The paragraph as amended reads as follows:

5. When the tensile strength determined by the test is less than 63,000 lb., the minimum elongation shall be 25 per cent. for plates ¾ in. and under in thickness and 22 per cent. for plates over ¾ in. in thickness. The quench-bend specimen shall bend through 180 deg. around a curve the radius of which is three-fourths the thickness of the specimen. When the tensile strength determined by the test is 63,000 lb. or greater the minimum elongation shall be 22 per cent. for plates ¾ in. and under in thickness and 20 per cent. for plates over ¾ in. in thickness. The quench-bend specimen shall bend through 180 deg. around a curve the radius of which is one and one-half times the thickness of the specimen. (See 4430, R. S.)

Argentina Machinery Markets

The field for the sale of machinery and machine tools in Argentina is attracting a great deal of attention from the trade. On this subject the Bureau of Foreign and Domestic Commerce has issued a 63-page report by Special Agent J. A. Massel, a mechanical engineer well versed in the commercial end of the business and thoroughly at home in Latin-American countries. This report should be studied carefully by everyone interested in the trade.

Argentina buys practically all its machinery and machine tools abroad, principally from England and Germany, for in this competition the United States has been a rather poor third. Our manufacturers now have an opportunity to get more of this trade and to keep it, and they should improve their knowledge of Latin-American conditions.

The bulletin is entitled "Markets for Machinery and Machine Tools in Argentina," Special Agents Series No. 116, and can be had for 20c. a copy by applying to the Superintendent of Documents, Washington, or by writing to the nearest district office of the Bureau of Foreign and Domestic Commerce.

Anti-Smoke Activity in Two Kentucky Cities

A campaign against the smoke evil in Louisville on a constructive basis has been begun under the direction of the Smoke Abatement League of that city, with Frank N. Hartwell, of H. Verhoeff & Co., grain dealers, as president. Leading citizens and the city officials are enrolled in the movement and participated in a mass meeting addressed by Osborn Monnett, of Chicago. It is the purpose of the league to raise a fund with which to employ a competent engineer to advise with manufacturers and the city authorities before a new ordinance is drawn up to supplant the present ineffective measure.

The Louisville "Times" estimates the annual losses and damages due to smoke in Louisville at nearly $2,000,000, the estimate being as follows:

Cost to smoke makers	$278,775.00
Cost to individuals in laundry and dry-cleaning bills	171,680.00
Cost to households (papering, painting, cleaning etc.)	417,000.00
Cost to business houses in damaged goods, etc..	1,090,000.00
Cost to quasi-public buildings (hotels, hospitals, etc.) for extra cleaning	37,000.00
Total	$1,994,355.00

This does not include losses in sale and rental values of real estate, the tremendous loss in efficiency because of ill health and many similar items for which bases of comparison are almost impossible to obtain, but which may easily increase this total by more than one-half.

Action by the city commission of Lexington, Ky., on a proposed anti-smoke ordinance, has been delayed pending further inquiry and comparison with the ordinance in effect in Cleveland, Ohio. I. N. Williams, of the Lexington Laundry Co.; Joseph LeCompte, of the Lexington Roller Mills Co.; James B. McKenna, of the Peerless Laundry, Carneal Kinkead, of the Kinkead Coal Co., and others, protested against the terms of the measure, stating that they were doing all in their power by means of stoking devices, etc., to prevent smoke, but that they were unable to do so and that the ordinance would impose serious handicaps on them.

Lap-Welded and Seamless Boiler Tube Specifications

Lap-welded and seamless boiler tubes for merchant and marine service shall be made of good-quality soft steel, rolled from solid ingots. Sufficient crop shall be cut from the ends to insure sound material. The permissible variation in weight is 5 per cent. above or below the calculated weight. Tubes shall have a reasonably smooth surface and be free from injurious pits, laminations, cracks, blisters, or imperfect welds; they shall also be free from kinks, bends and buckles, signs of unequal contraction in cooling or injury during manufacture. The thickness of the walls shall not vary more than 10 per cent. above or below the gage specified, except at the weld, where 0.015 in. extra thickness will be allowed. Tubes shall not vary more than ½ per cent. either way from being round or true to the mean outside diameter, except in the smaller sizes, where a variation of 0.015 in. will be accepted. Tubes shall not be shorter than the length ordered nor more than 0.125 in. longer.

Flattening Test—A section 3 in. long shall stand hammering flat cold until the inside walls are within three times the thickness of the material without cracking at the bend or elsewhere. In case of lap-welded tubes for marine work, the bend at one side shall be made in the weld. For marine purposes on lap-welded tubes 4 in. and smaller, and on all sizes of seamless tubes, a flange ⅜ in. wide shall be bent over at right angles to the body of the tube without showing cracks or opening at the weld. Each lap-welded tube shall be subjected by the manufacturer to an internal hydrostatic pressure for the respective sizes and gage as given and agreed upon. All seamless boiler tubes are tested to 1,000 lb. per sq.in.

In addition to the foregoing tests, each tube when inserted in the boiler must stand expanding and flanging where required without cracking or opening at the weld. Tubes that fail in this way may be returned to the manufacturer. A certificate of test shall be furnished the purchaser of each lot of tubes for marine service, describing the kind of material from which they are made, and that the tubes have been tested and have met all the requirements described by the Board of Supervising Inspectors, Department of Commerce, Steamboat Inspection Service.—National Tube Company.

PERSONALS

Charles Parkins, formerly engineer of The Lustra Leather Co., Elizabeth, N. J., is now connected with the American Can Co., Kenilworth, N. J., as chief engineer.

Max Reich has left the employ of the De La Vergne Machine Co., New York, to take the position of chief engineer with the Hudson Ice Co., Jersey City, N. J.

Howard F. Bucklew, formerly an electrician with the Alpha Portland Cement Co., at Manheim, W. Va., is now a mechanic with the Preston Auto Co. at Kingwood, W. Va.

P. E. Mack, formerly with the Atlantic Terra Cotta Co., Perth Amboy, N. J., has been appointed chief engineer for the new municipal electric-light plant at Perth Amboy.

F. H. Chamberlain, general manager of the Alabama Power Co., Birmingham, Ala., has resigned to accept a position as vice-president of the Calco Chemical Co., of Bound Brook, N. J.

H. W. Caudle has been elected by the City Council of Lagrange, Ga., as manager of the municipal electric-light plant to fill the vacancy caused by the resignation of R. W. Underwood.

Curtis Duke, until recently chief engineer of the Ft. Wayne-Springfield R.R. at Decatur, Ind., now occupies the same position with the Hoopeston Gas and Electric Co. at Hoopeston, Ill.

J. M. Hopwood has accepted a position with the George J. Hagen Co., Pittsburgh, Penn., as sales manager of its stoker and specialty department. His previous position was that of superintendent of power for the West Penn Traction Co., Pittsburgh, Penn.

Francis C. Shenehon, member of the American Society of Civil Engineers, for the past seven years dean of the College of Engineering and professor of civil engineering at the University of Minnesota, has tendered his resignation to the Board of Regents. Mr. Shenehon will devote his entire time to his practice as a consulting hydraulic engineer.

BOOKS RECEIVED

MECHANICAL ENGINEERS' HANDBOOK. By Lionel S. Marks. McGraw-Hill Book Co., Inc., New York. Flexible leather; 4¾x7¼ in.; 1836 pages; tables; copiously illustrated. Price, $5.

THE CHEMICAL EXAMINATION OF WATER, FUEL, FLUE GASES AND LUBRICANTS. By S. W. Parr. Published by the author at Urbana, Ill. Cloth; 6x9¼ in.; 130 pages; 26 illustrations; tables. Price, $1.50.

NEW PUBLICATIONS

COST ACCOUNTING, THEORY AND PRACTICE. By J. Lee Nicholson, C. P. A. The Ronald Press Co., New York. Cloth; 6x9 in.; 341 pages; 4 charts. Price, $4.

The author is of the firm of J. Lee Nicholson & Co., certified public accountants, and is instructor in cost accounting at Columbia University. His work, which has just received its second printing, is designed as a reference book for public accountants, a simple exposition of the principles involved for the student, and an explanation of the practical points involved for the manufacturer.

"Power costs," says the author, "are somewhat complex, especially where a factory produces its own power. The power plant is regarded as a department by itself and bears its own assignment of direct as well as certain indirect expenses. If the power plant furnishes heat and light to the factory, the cost of these items must be subtracted from the total power costs to get the net power cost applying to production centers."

STEAM TRACTION ENGINEERING. By S. R. Eighinger and Marcus Smedes Hutton. Published by D. Appleton & Co., New York and London, 1916. Cloth; 5½x8 in.; 300 pages; 92 illustrations. Price, $2.50 net.

This book, for the use of practical men in charge of steam traction or portable engines, is written in such terms and form as to be easily understood by the nontechnical, yet is correct as to the principles involved. It includes information on boilers and their accessories, how to keep them in operating condition, engine mechanism and its care and management and suggestions as to handling an engine on the road

and in difficult places. A section of particular merit is that dealing with valves and valve gears, in which full instruction in the method of setting valves with a great variety of reversing gears is set forth. The appendix contains questions frequently asked at examinations for license to operate such engines and answers in a form that will be satisfactory to the examiner. As a whole the book should be of great assistance to the steam-traction operating man, as it is well prepared and comprehensive in its field.

GAS ENGINE IGNITION. By E. B. Norris, R. K. Winning and W. C. Weaver. Published by McGraw-Hill Book Co., New York, 1916. Cloth; 6x8 in.; 174 pages, illustrated. Price, $1.50.

The material for this book was prepared as part of the extension course of the University of Wisconsin and is largely descriptive in character. The first chapter is devoted to the different methods of ignition used with internal-combustion engines; this is followed by an explanation of the jump-spark battery systems, nonvibrating coils, batteries, magnetos and generators. The operations of several well-known systems are described and illustrated.

Written primarily as a textbook, the matter has been arranged with particular reference to home study. It should also find a field among automobile repairmen.

COAL, ITS ECONOMICAL AND SMOKELESS COMBUSTION. By J. F. Cosgrove. Published by the Technical Book Publishing Co., Philadelphia, 1916. Size, 8x5½ in.; 273 pages, illustrated. Price, $3.

A book for the mechanical engineer, operating engineer or student, covering the classifications of coals according to their carbon and hydrogen contents, their carbon and oxygen contents and their carbon-hydrogen ratio, also according to use; the characteristics of different coals; clinkering, its cause and how best to avoid it; a brief geological history of coal; the theory of combustion; determination of heat value; furnaces for smokeless combustion; stokers and firing methods. An appendix contains the ultimate and proximate analysis of some 319 American coals.

INDUSTRIAL ARTS INDEX. Published by the H. W. Wilson Co., White Plains, N. Y. Subscription rates based on number of periodicals taken.

This is a cumulative index of the important articles in about eighty engineering and trade publications. It is issued five times a year, the December number being the annual cumulation, and is bound in library buckram.

Abnormal Coefficients of the Venturi Meter

The basic formula for the discharge from a venturi meter is $Q = CA\sqrt{\frac{2gh}{\left(\frac{A}{a}\right)^2 - 1}}$ cu.ft. per sec., where A and a are respectively the areas at the entrance and throat of the meter, and h the difference of head in ft. of water at these points. The mean value of the constant C varies from about 0.95 to 1. Comparatively few series of experiments are available in which the variation of C has been measured over a wide range of velocities, but those that are available show that for fairly high velocities of flow the variation in C is remarkably small. At smaller velocities, however, the variation in C may be surprisingly large.

Apart from errors of observation or of measurement, there would appear to be four possible explanations of abnormal values of C: (1) some error in the basic equation due to failure to take into account all the hydrodynamical factors involved; (2) some abnormal feature in the conditions governing the flow toward the meter, (3) some abnormal feature in the design or proportions of the meter; (4) failure of the registering columns to record the true pressures at entrance to, or at the throat of the meter.

A paper by A. H. Gibson. (Inst. Civ. Eng., "Proc. 199," pp. 391-408, 1914-1915) is devoted to a consideration of these points. The conclusions drawn are: (a) In any meter in good order and of normal proportions, friction does not affect the value of C by more than about 2 per cent. so long as the diameter of the pipe line is greater than about 2 in. (b) With pipe-line velocities less than about 0.5 ft. per sec., the steadying of the velocity at the throat causes a distribution of velocity under which the kinetic energy at the throat is appreciably greater than $\frac{v^2}{2g}$ ft. (c) Values of C obtained from a meter when measuring a pulsating flow are less than with a constant flow. (d) The effect of whirl in the water approaching the meter is to increase the value of C. (e) Where the pressure orifice at throat or entrance consists of a circumferential gap, the width of this gap has some effect on the value of C. (f) Abnormally high values of C at moderately low velocities are to be attributed to errors in the throat-gage reading, due to the accumulation of air at the throat.—"Science Abstracts."

MISCELLANEOUS NEWS

Rhode Island Co.'s Station Improves—The Rhode Island Co.'s large station on South St., Providence, has lately undergone some changes to modernize the plant which carries practically the entire railroad load of the state. The new Bigelow-Hornsby water-tube boilers have carried 26,000 kw. with 5,000 rated boiler horsepower capacity, giving 5.2 kw. per rated boiler horsepower. The fuel is Pocahontas run-of-mine burned on Taylor underfeed stokers; the steam pressure is 200 lb. with 125 deg. F. superheat, and the 15,000-kw. vertical Curtis turbines carry 28 in. vacuum.

TRADE CATALOGS

Wagon and Truck Loaders. Jeffrey Mfg. Co., Columbus, Ohio. Bulletin No. 177. Pp. 24. 6x9 in.; illustrated.

Alternating Current Generators. Allis-Chalmers Mfg. Co., Milwaukee, Wis. Bulletin No. 1098. Pp. 20, 8x11½ in. Illustrated.

Belted Alternating Current Generators. Allis-Chalmers Mfg. Co., Milwaukee, Wis. Bulletin No. 1099. Pp. 16. 8x11½ in. Illustrated.

Monash Vacuum System of Steam Heating. Monash Engineering Co., 1407-17 W. Jackson Blvd., Chicago, Ill. Bulletin No. 40. Pp. 28; 6x9 in.; illustrated.

Carrier Generator Cooler. Carrier Air Conditioning Co. of America, Buffalo, N. Y. Bulletin No. 253. Pp. 24; 6x9 in.; illustrated. This describes the cooling and cleaning of air for generator and transformer ventilation.

Fine Mechanical Tools. The L. S. Starrett Co., Athol, Mass. Catalog No. 21. Pp. 336. 5x7½ in. This contains illustrations and descriptions of the extensive line of small tools and additions to the line. A new list is included.

Trill Indicators. Trill Indicator Co., Corry, Penn. Catalog. Pp. 56. 6x9 in. Illustrated.
This describes the latest types of engine indicators and accessories made by this company, with information on taking and reading of indicator cards.

Hunt Cut-Off Valves. C. W. Hunt Co., West New Brighton, N. Y. Catalog No. 15-3. Pp. 28. 6x9 in.
This catalog contains illustrations and complete descriptions of standard gates or valves for controlling the flow of bulk materials.

Heating Specialties. American Radiator Co., 816-22 South Michigan Ave., Chicago, Ill. Catalog. Pp. 336; 3½x6½ in. This is the 1916 edition of the Ideal Fitter illustrating and describing the radiators, boilers, heaters, etc., built by this company and contains a lot of data which should be useful to anybody interested in heating and ventilating problems.

BUSINESS ITEMS

The Jeffrey Manufacturing Co. has opened new branch offices at Dallas, Tex., and St. Louis, Mo. The Dallas office will be in the Commonwealth National Bank Building and will be in charge of J. U. Jones. W. V. Cullen has been placed in charge of the St. Louis office, with headquarters in Room A-21 of the Railway Exchange Building.

The Diamond Power Specialty Co., Detroit, Mich., has contracted with the Ford Motor Co. to equip the boilers in its new power plant with Diamond soot blowers. These are believed to be the largest boilers in the world. Their rated capacity is 2,400 hp. and it is planned to operate them continuously at 4,000 hp. Before closing this contract the Ford Motor Co. conducted a series of tests on the patented metal Insuluminum of which Diamond blowing units are constructed. It was found that calorized metal would withstand without scaling or warping a continuous temperature of 1,800 deg. F. and as a result the Ford company is planning to use the new material in its carbonization process.

Classified Ads

appear on pages 140 and 141 of this issue and will in future appear in the same relative position in the paper. Page numbers will be given in the Table of Contents under the heading "Special Opportunities Section."